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AFFDL-TR-74-98

AD B000147

ADVANCED METALLIC AIR VEHICLE STRUCTURE PROGRAM

THIRD INTERIM REPORT

General Dynamics
Fort Worth Division

TECHNICAL REPORT AFFDL-TR-74-98

JUNE 1974

Air Force Flight Dynamics Laboratory
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio 45433

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AIR FORCE/56780/8 November 1974 — 350

ADVANCED METALLIC AIR VEHICLE STRUCTURE PROGRAM

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FOREWORD

This report covers the period 16 December 1973 through 15 June 1974. The efforts reported herein were sponsored by the Air Force Flight Dynamics Laboratory (AFFDL) under joint management and technical direction of AFFDL and the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

This work was performed under contract F33615-73-C-3001 "Advanced Metallic Air Vehicle Structure" (AMAVS) as part of the Advanced Metallic Structures, Advanced Development Programs (AMS ADP), Program Element Number 63211F, Project Number 486U. John C. Frishett, Major, USAF, is the ADP Manager while Mr. Charles R. Waitz is the Project Engineer for the AMAVS Program.

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J. L. McDaniel	- Manufacturing Engineering
Dr. H. I. McHenry	- Fracture and Fatigue Analysis
R. E. Miller	- Stress Analysis
W. O. Sunafrank	- Manufacturing Engineering
J. M. Shults	- Materials Engineering
A. F. Stern	- Structural Design
W. M. Walker	- Test Coordination
D. Clayton	- Full Scale Test Planning

This work was performed during the period 16 December 1973 to 15 June 1974. It was submitted by the authors in June 1974.

This technical report has been reviewed and is approved for publication.

Charles R. Waitz
Project Engineer

John C. Frishett, Major, USAF
Program Manager
AMS Program Office
Structures Division

A B S T R A C T

This report covers the design, analysis, manufacturing and testing done during the last portion of Phase II, detail design, and the first portion of Phase III, Fabrication, of the Advanced Metallic Air Vehicle Structure (AMAVS) program. All drawings for the wing carrythrough structure, simulated fuselage and test fixture were completed and significant progress was made in manufacturing each of these items.

A weight reduction effort was necessary in order to meet the weight reduction goal for the wing carrythrough structure after incorporation of the updated loads data. This effort has been completed and was successful.

Delivery of material for manufacture of the wing carrythrough structure is complete except for the 10 Ni steel for the upper lugs.

Manufacturing processes successfully completed include flame cutting of thick plates of 10 Ni steel and beta annealed 6Al-4V titanium, Electron Beam (EB) welding of both of these materials, Gas Tungsten Arc (GTA) welding of 10 Ni steel, machining of 10 Ni steel and 6Al-4V titanium and bonding of titanium sandwich panels. Most tooling for detail parts is complete and the assembly fixtures are complete.

Assembly of the simulated fuselage structure was started and is scheduled for completion in July 1974. All of the test fixture will be completed by December 1974.

Additional materials and component testing has been approved as an addition to the original contract. Plans for these tests have been made and some tests are being conducted. All materials and component testing authorized by the original contract has been completed.

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LIST OF ILLUSTRATIONS
(CONTINUED)

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF ILLUSTRATIONS
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LIST OF ILLUSTRATIONS
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LIST OF ILLUSTRATIONS
(CONTINUED)

LIST OF TABLES

LIST OF TABLES
(CONTINUED)

SECTION 1

INTRODUCTION

This interim report summarizes the accomplishments of the Advanced Metallic Air Vehicle Structure Program from 16 December 1973 to 15 June 1974. This work is part of the Air Force's Advanced Metallic Structures, Advanced Development Program. It was performed under contract to the AFFDL by the Convair Aerospace Division of General Dynamics at Fort Worth, Texas.

The six months covered by this report include the last portion of Phase II, Detail Design, and the first portion of Phase III, Fabrication. Tasks accomplished in Phase II were reported in AFFDL-TR-74-17 dated January 1974 and included the following significant items:

1. Revised production designs to incorporate the latest updated loads and technical data from the baseline airplane.

2. Completed production drawings for both the Fail Safe Integral Lug (FSIL) and the "No-Box" Box (NBB) configurations.

3. Selected the NBB 10 Nickel Steel (HY180) configuration for manufacture in Phase III.

All material necessary for the manufacture of the NBB has been received except for the 3-inch-thick 10 Nickel steel plate required for the upper lugs. This material is expected in July 1974.

Manufacturing Research and Development has accomplished significant achievements in flame cutting of both 10 Nickel steel and 6Al-4V beta annealed titanium, electron beam welding of 10 Nickel steel in thickness up to 1.8 inches, and in efficient cutting, drilling and reaming of 10 Nickel steel.

Planning of the simulated fuselage and the NBB is substantially complete. Tool design and manufacture is progressing in accordance with the established production schedule. The lower plate assembly fixture for manufacturing station number 1 is complete and the assembly fixture for stations 2 through 5 is in work.

Detail part manufacture of the simulated fuselage is complete and good progress is being made on NBB detail parts. The 10 Nickel steel lower plate and reinforcing lugs are complete. The Y_F932 and Y_F992 10 Nickel steel bulkheads have been electron beam (EB) and gas tungston arc (GTA) welded. All detail parts are complete for the titanium sandwich lower plate panels. The titanium drag brace fittings have been EB welded and are now in final machining.

Assembly of the simulated fuselage has been started and completion is expected in July 1974. Assembly of the NBB will start in July 1974 and completion is scheduled for January 1975.

Good progress is being made in the manufacture of the test fixture structure. The test fixture base and the wing sweep actuator system are complete. The dummy main landing gears are complete except for machining of two large castings. The dummy wings for applying loads to the NBB are in final assembly. The upper structure continues in work with completion scheduled for November 1974. The loading system is in work and scheduled for shipment with the test fixture base to Wright Patterson Air Force Base in August 1974. Testing at WPAFB is scheduled to start in April 1975.

SECTION 2

TECHNICAL DISCIPLINES PROGRESS

The progress made by the technical groups during the beginning of Phase III, Manufacturing, is reported in this section.

2.1 ENGINEERING

The engineering functions progress for the period 16 December 1973 to 15 June 1974 is detailed below.

2.1.1 Structural Design

All production drawings for the "No-Box" Box wing carry through structure were released for fabrication.

The overall assembly drawing for the "No-Box" Box, X7224001, is shown in Figures 2.1.1-1 through 2.1.1-6. Component and subassembly drawings except for the main landing gear and wing sweep actuator fittings are shown in Report No. AFFDL-TR-74-17. These fitting drawings are shown in this report.

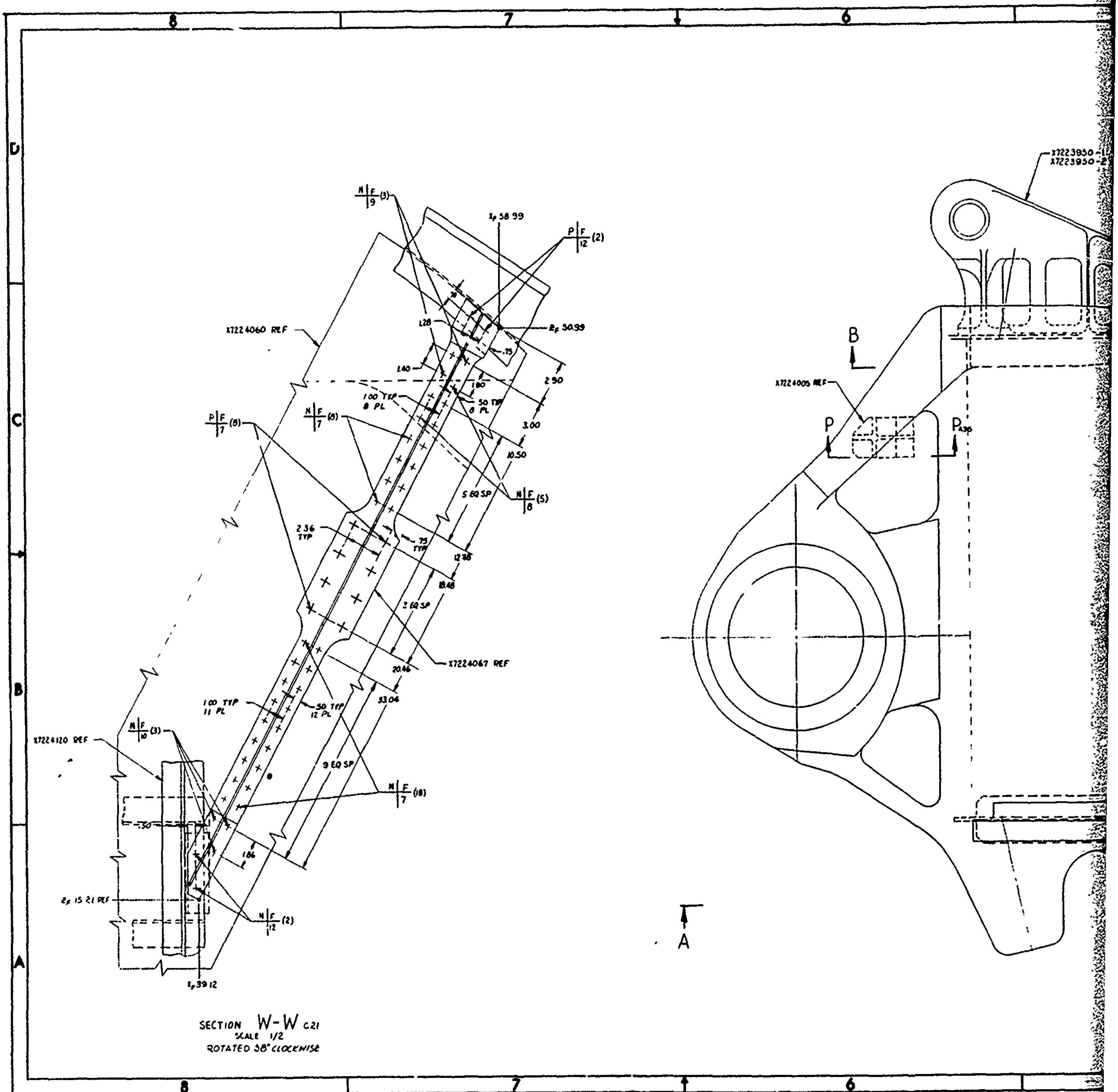
2.1.1.1 Weight Reduction Activity

In mid-January, 1974, as the "No-Box" Box drawings were nearing completion, the weight of the WCTS was projected to be approximately 13,500 lbs. This was 1000 pounds over the weight shown at the end of Phase II and was considered to be unacceptable. As a result of this overweight condition, a weight reduction effort was initiated and resulted in the current weight status shown in paragraph 2.1.2.9, a reduction of nearly 1000 pounds.

Forty-seven drawings were reviewed to determine potential weight reductions. As a result of this review, thirty-five changes were made to released drawings and weight reduction changes were incorporated on six drawings prior to release.

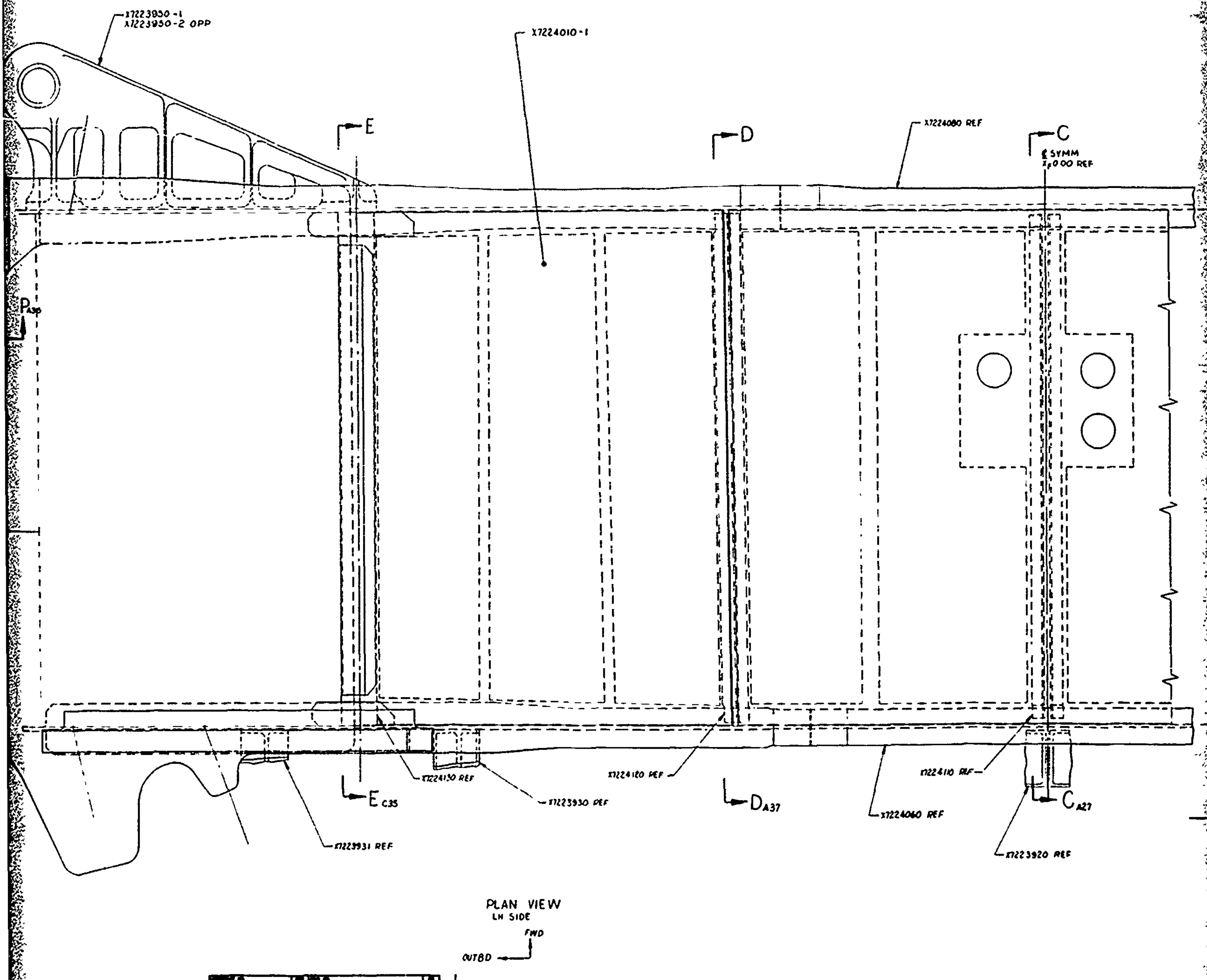
The degree of weight reduction incorporated was influenced by the cost impact. The major portion of the weight reduction was achieved by reducing machined thicknesses in local areas. Significant weight savings were realized by changing the side load fitting and two gussets on the Y_F932 bulkhead from 10 Nickel steel to beta processed 6Al-4V titanium.

No changes were made to six of the drawings reviewed because of excessive cost for the amount of the weight reduction possible.



X7224060 REF
X7224067 REF
X7224120 REF
X7224005 REF
X7223950-1
X7223950-2
2.90
3.00
10.50
5 EQ SP
12.78
18.48
2 EQ SP
20.46
53.04
9 EQ SP
1.00 TYP
8 PL
.50 TYP
8 PL
1.00 TYP
11 PL
.50 TYP
12 PL
2.36
TYP
.75
TYP
1.86
B
P
A
SECTION W-W C21
SCALE 1/2
ROTATED 38° CLOCKWISE

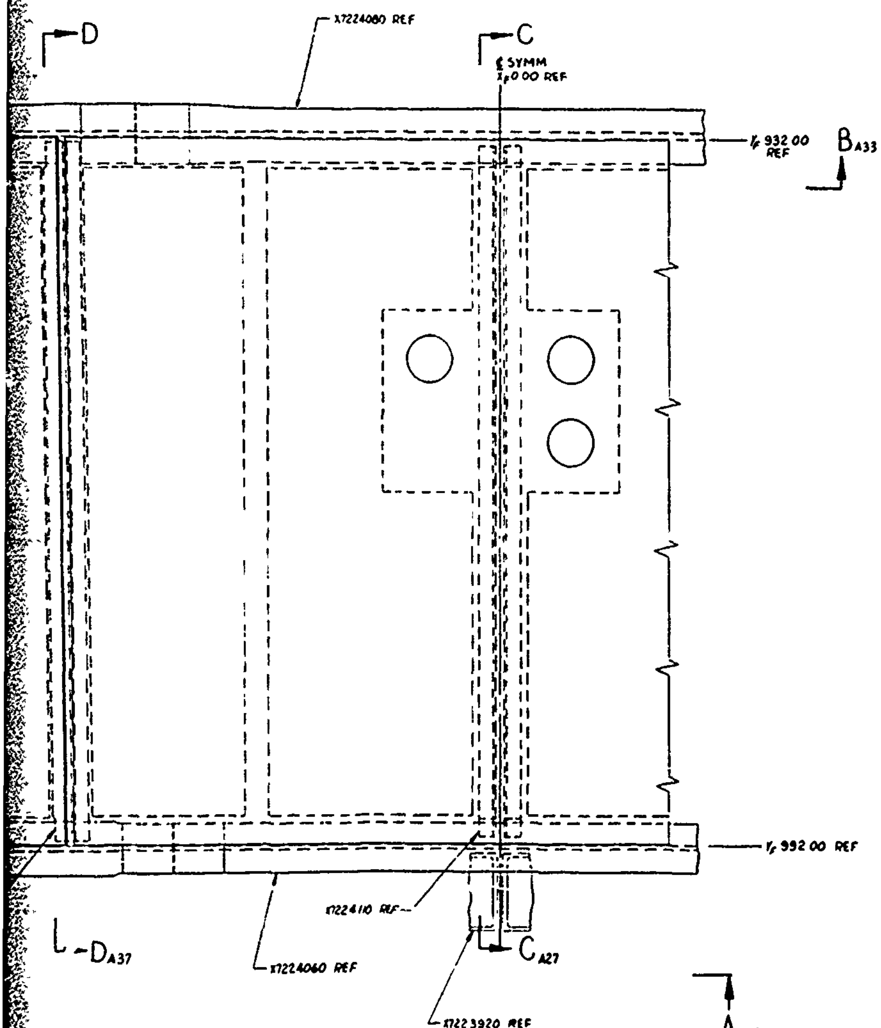
5 4 3



F33615-73-C-3001 | X7224001 | 1

5 4 3

2



9 FASTENER CODE:

BASIC CODE — HEAD LOCATION (N) NEAR SIDE (F) FAR SIDE NO CODE = LOCATION OPTIONAL — GRIP LENGTH DASH NO.

BASIC CODE	HOLE DIA	FASTENER	NUT 81755/	WASHER UNDER HEAD	WASHER UNDER NUT	TORQUE PER	INSTL SPEC
A	SEE SPEC	X7223999-6-	C389-6	81755/P511-10	X7223986-6	INSTL SPEC	X7223993-6
B	SEE SPEC	X7223999-7-	C389-7	81755/P511-13	X7223986-7	INSTL SPEC	X7223993-7
C	SEE SPEC	X7223999-8-	C389-8	81755/P511-16	X7223986-8	INSTL SPEC	X7223993-8
D	SEE SPEC	X7223999-10-	C389-10	81755/P511-22	X7223986-10	INSTL SPEC	X7223993-10
E	SEE SPEC	X7223999-12-	C389-12	81755/P511-24	X7223986-12	INSTL SPEC	X7223993-12
F	SEE SPEC	X7223999-14-	C389-14	81755/P511-27	X7223986-14	INSTL SPEC	X7223993-14
G	.3710 .3746	X7223996-6-	C077-6	X7223992-6	X7223994-6	81755/M06-6B	NONE
H	.4335 .4371	X7223996-7-	C077-7	X7223992-7	X7223994-7	81755/M06-7B	NONE
J	.5025 .4996	X7223996-8-	C077-8	X7223992-8	X7223994-8	81755/M06-8B	NONE
K	.6215 .6241	X7223996-10-	C077-10	X7223992-10	X7223994-10	81755/M06-10B	NONE
L	.5025 .4996	81755/C4550-8-	C077-8	X7223992-8	X7223994-8	81755/M06-8B	NONE
M	.6215 .6241	81755/C4550-10-	C077-10	X7223992-10	X7223994-10	81755/M06-10B	NONE
N	.2520 .2496	81755/C020-8-	C2950-8	X7223991-8	NONE	81755/M06-4A	NONE
P	.3710 .3746	81755/C020-12-	C2950-12	X7223991-12	NONE	81755/M06-6A	NONE
R	.5650 .5617	X7223996-9-	C077-9	X7223992-9	X7223994-9	81755/M06-9A	NONE
S	.3145 .3121	81755/C020-10-	C2950-10	X7223991-10	NONE	81755/M06-5B	NONE

8. -1 CONTAINS FRACTURE CRITICAL DETAILS. RETAIN ORIGINAL DETAIL MATL TRACEABILITY NUMBERS IN ACCORDANCE WITH X7224198.
7. MARK ASSY NO. PER X7224198 CLASS 2 A.
6. PROTECTIVE FINISH NOTED SPOTFACES AS FOLLOWS:
   A. CLEAN AND APPLY CHEMICAL FILM PER MIL-C-5541
   B. APPLY TWO COATS MIL-P-23377 EPOXY-POLYAMIDE PRIMER PER MIL-F-18264.
5. SURFACE ROUGHNESS OF ALL STRAIGHT SHANK FASTENER HOLES SHALL NOT EXCEED 125.
4. CLEAN NOTED FAYING SURFACES AND APPLY -9 MOLDED SHIM PER 81755/FPS-1071 CLASS II, TYPE II.
3. SEALING MATERIALS AND METHODS OF APPLICATION PER X7224196.
2. APPLY -7 GENERAL SEALANT TO ALL FAYING SURFACES AND TO SHANK OF ALL STRAIGHT SHANK FASTENERS.
1. DIMENSIONS AND TOLERANCES PER USASI Y14.5.

NOTES (EXCEPT AS SHOWN)

REV STATUS	
SH	REV
1	-
2	-
3	-
4	-
5	-
6	-

Figure 2.1.1-1

SEE SEPARATE PARTS LIST

NEXT SECTION LETTER: AM

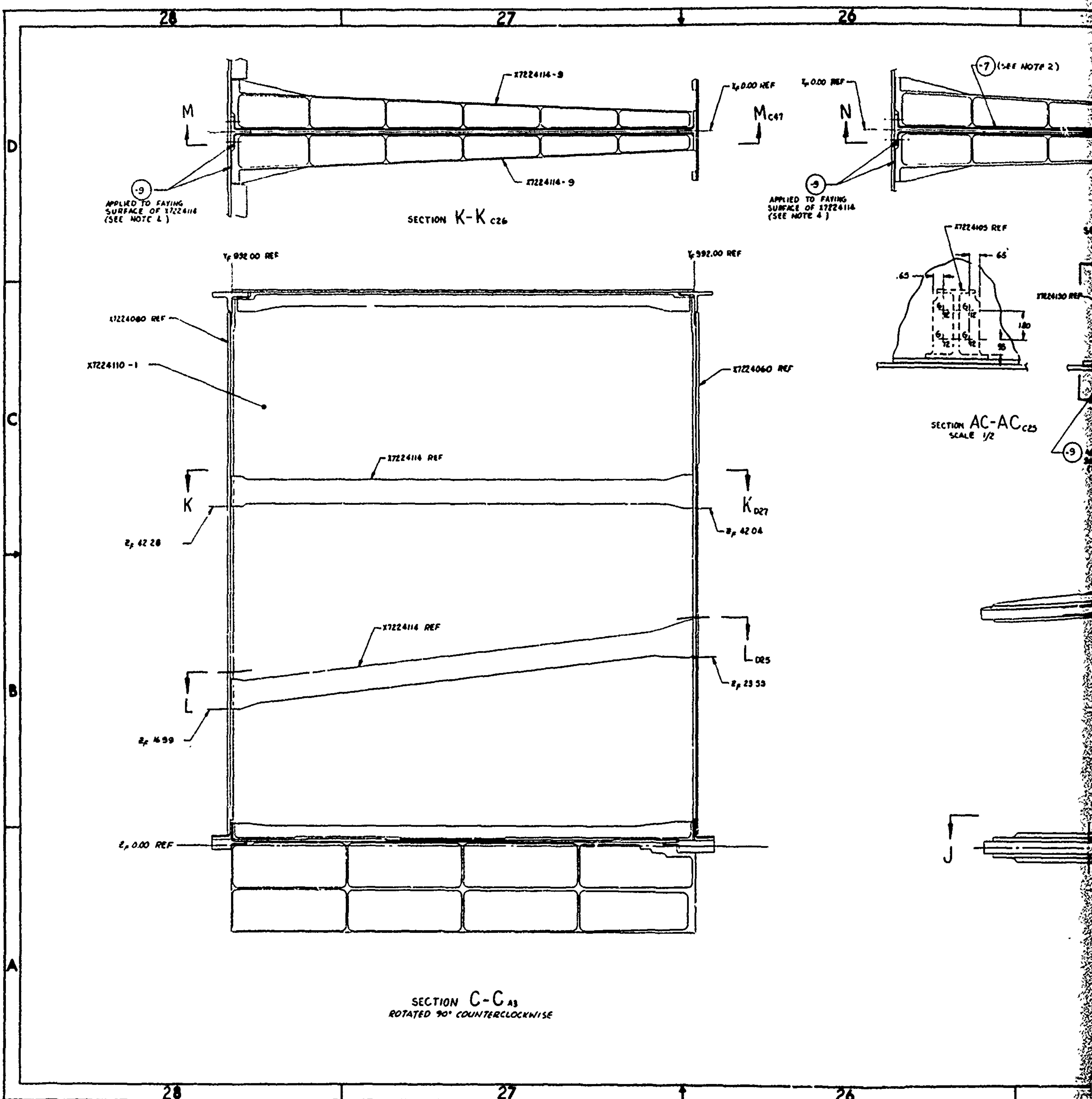
SEE PL

SEE NOTE 6

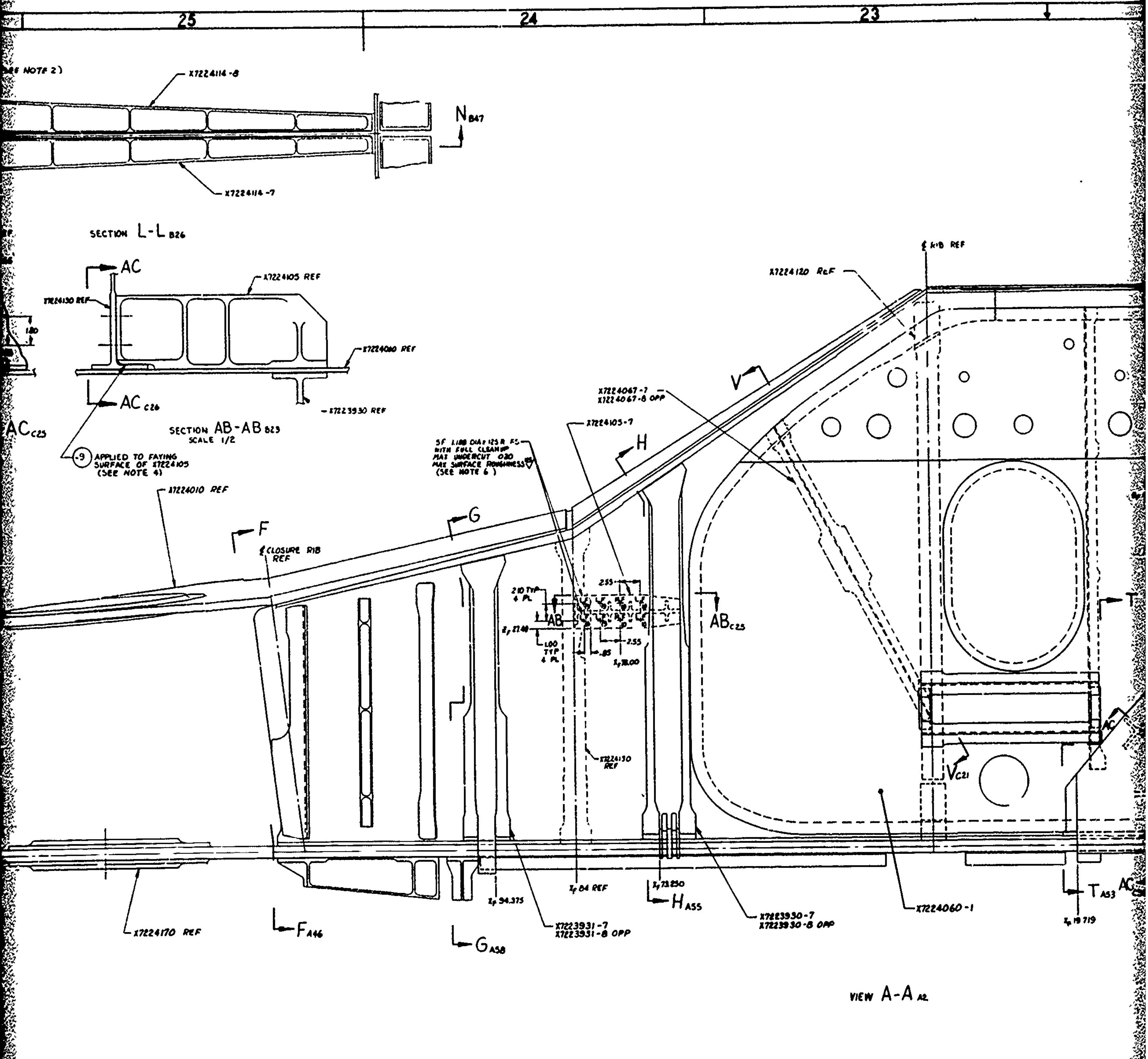
GENERAL DYNAMICS

SUPPORT ASSY, WING PIVOT - Y_F 932 TO Y_F 992

J 07878 X7224001



28
27
26
D
C
B
A
X7224114-9
Y_F 0.00 REF
M
M_{C47}
N
-7 (SEE NOTE 2)
-9
APPLIED TO FAYING SURFACE OF X7224114 (SEE NOTE 4)
SECTION K-K C26
X7224105 REF
.65
.65
1.80
.35
X7224130 REF
SECTION AC-AC C25
SCALE 1/2
Y_F 992.00 REF
X7224080 REF
X7224110 -1
X7224060 REF
X7224114 REF
K
K_{D27}
Z_F 42.28
Z_F 42.04
L
L_{D25}
Z_F 23.53
Z_F 16.99
Z_F 0.00 REF
J
SECTION C-C A3
ROTATED 90° COUNTERCLOCKWISE



F33615-73-C-3001	X7224001	2

25 24 23

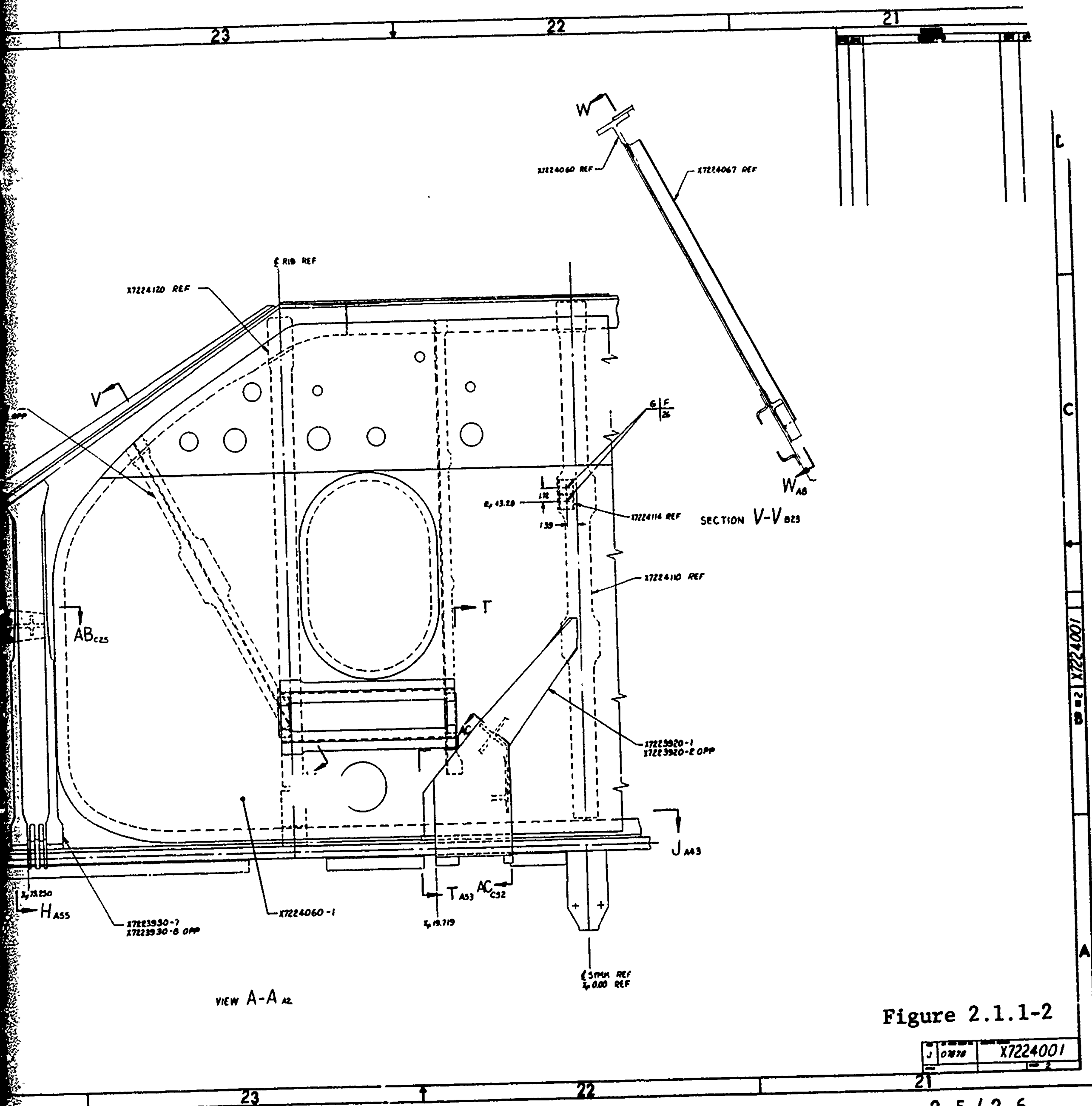
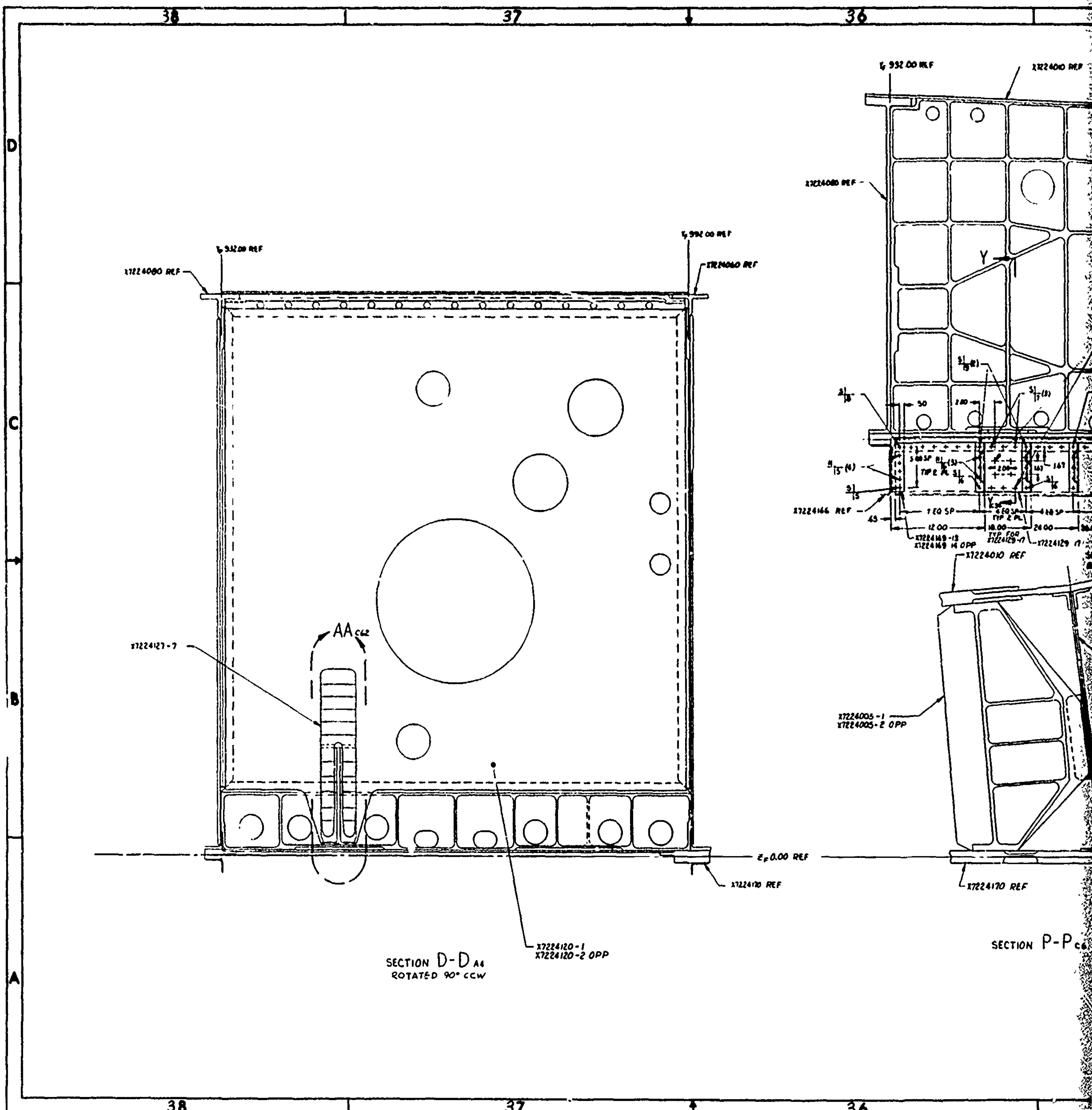
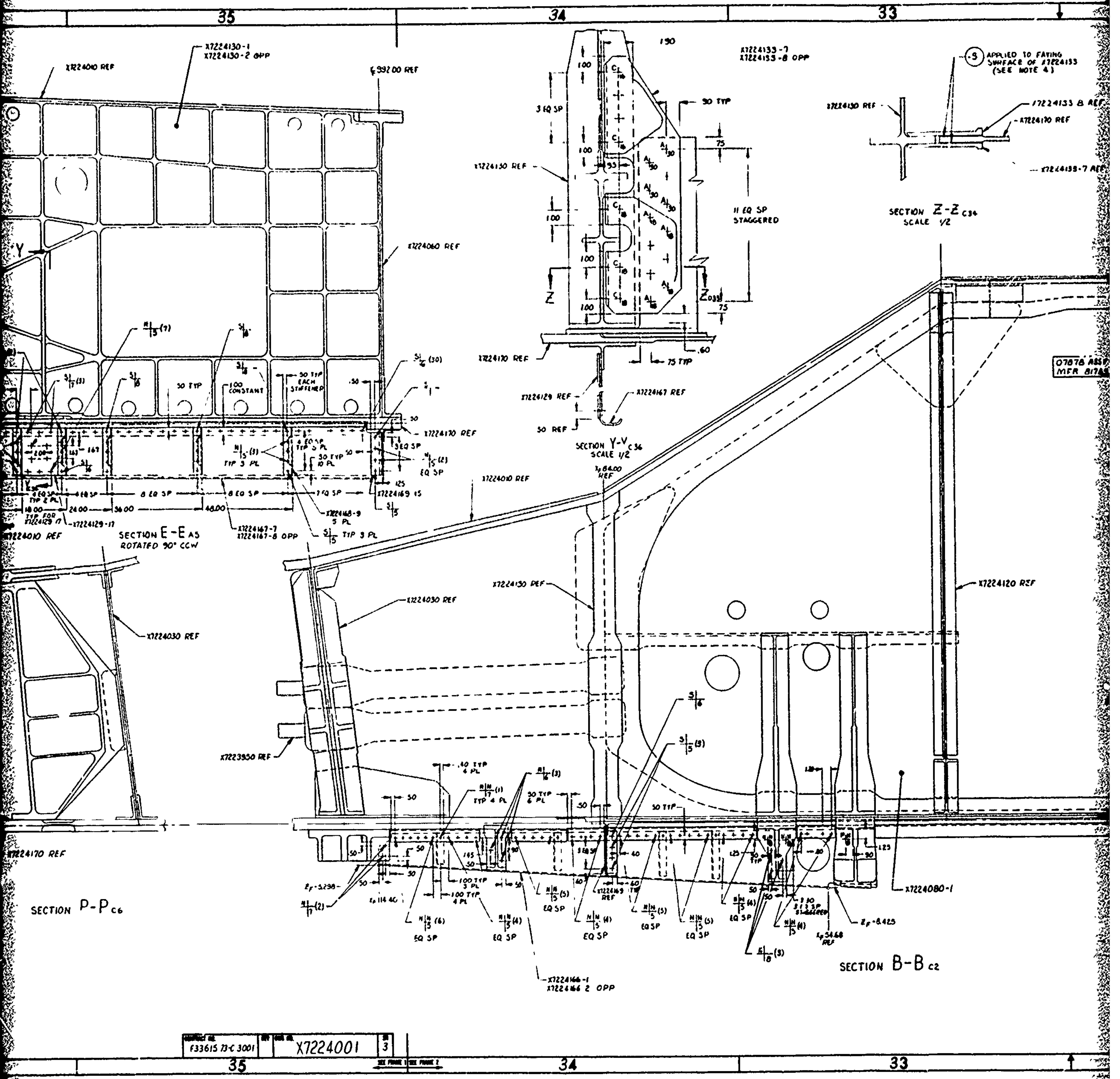


Figure 2.1.1-2

3


38
37
36
D
C
B
A
X7224080 REF
X7224080 REF
X7224121-7
AA C62
X7224120-1
X7224120-2 OPP
X7224170 REF
X7224010 REF
X7224005-1
X7224005-2 OPP
X7224166 REF
X7224170 REF
SECTION D-D A4
ROTATED 90° CCW
SECTION P-P


35
34
33
X7224130-1
X7224130-2 OPP
X7224010 REF
X7224060 REF
X7224133-7
X7224133-8 OPP
APPLIED TO FAYING SURFACE OF X7224133 (SEE NOTE 4)
X7224130 REF
X7224170 REF
SECTION Z-Z C34
SCALE 1/2
11 EQ SP
STAGGERED
X7224129 REF
X7224167 REF
SECTION Y-Y C36
SCALE 1/2
SECTION E-E A5
ROTATED 90° CCW
X7224030 REF
X7224120 REF
X7223950 REF
X7224080-1
SECTION P-P C6
SECTION B-B C2
X7224166-1
X7224166-2 OPP
F33615 73-C 3001
X7224001
3

2

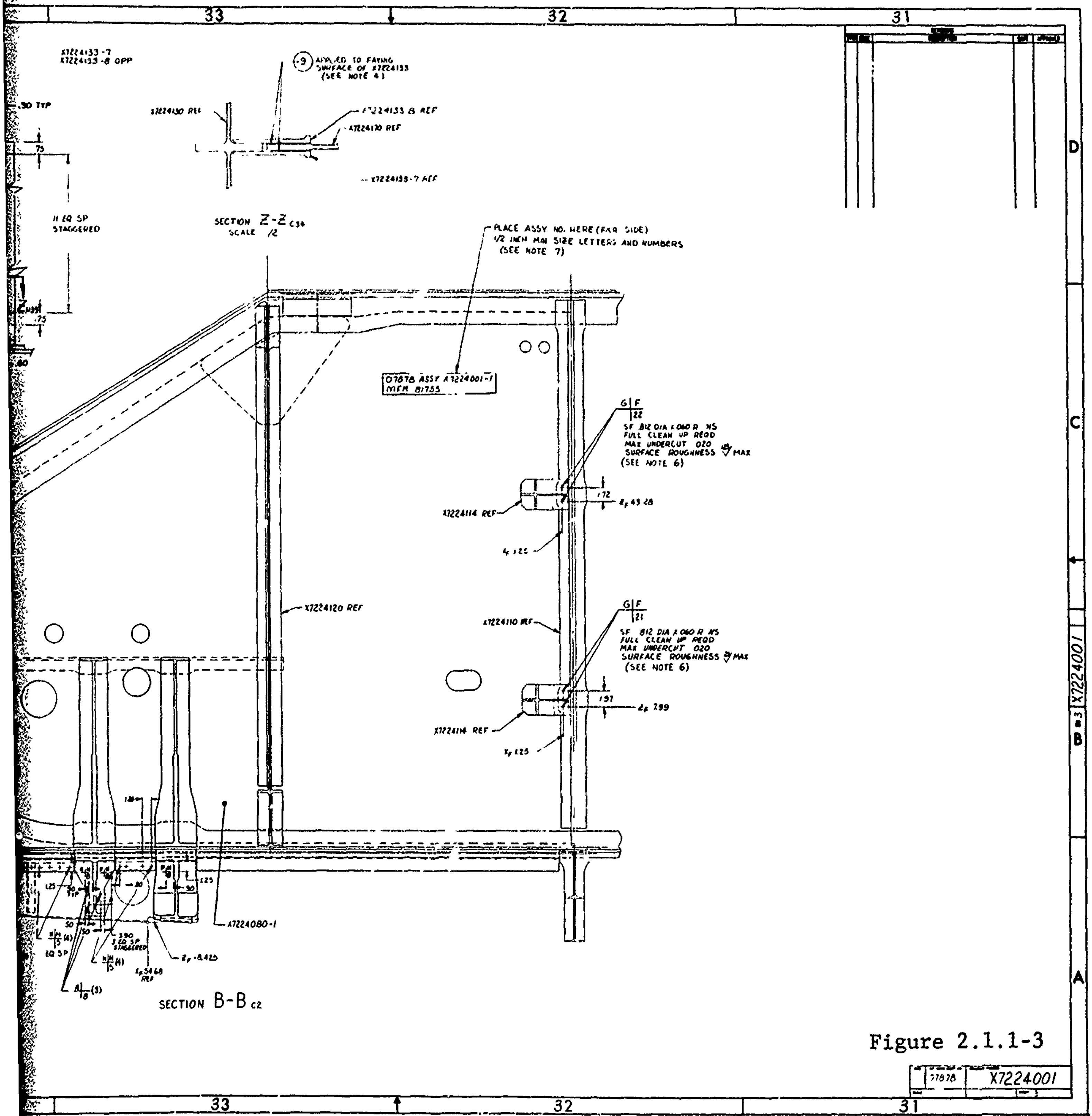
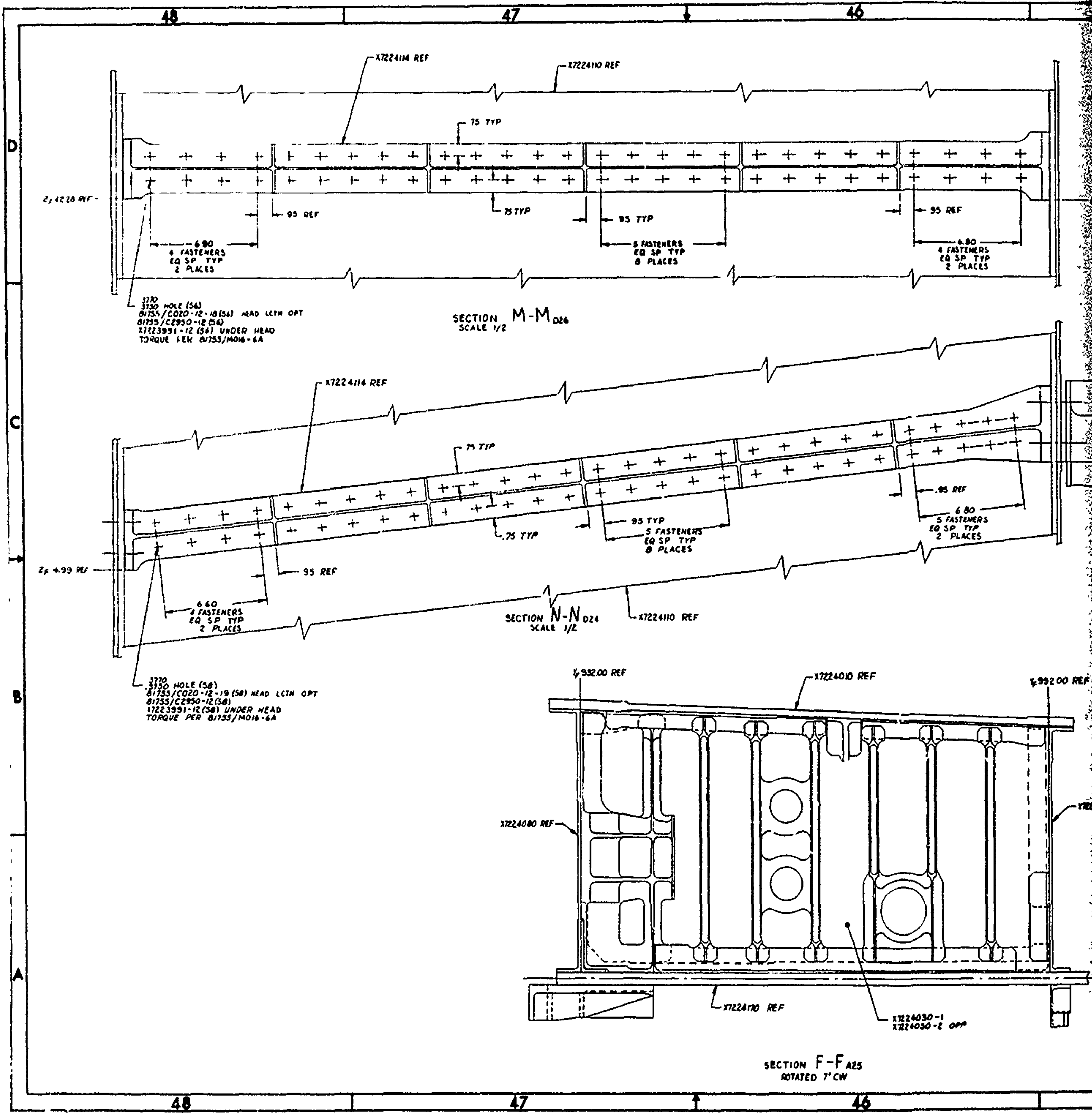
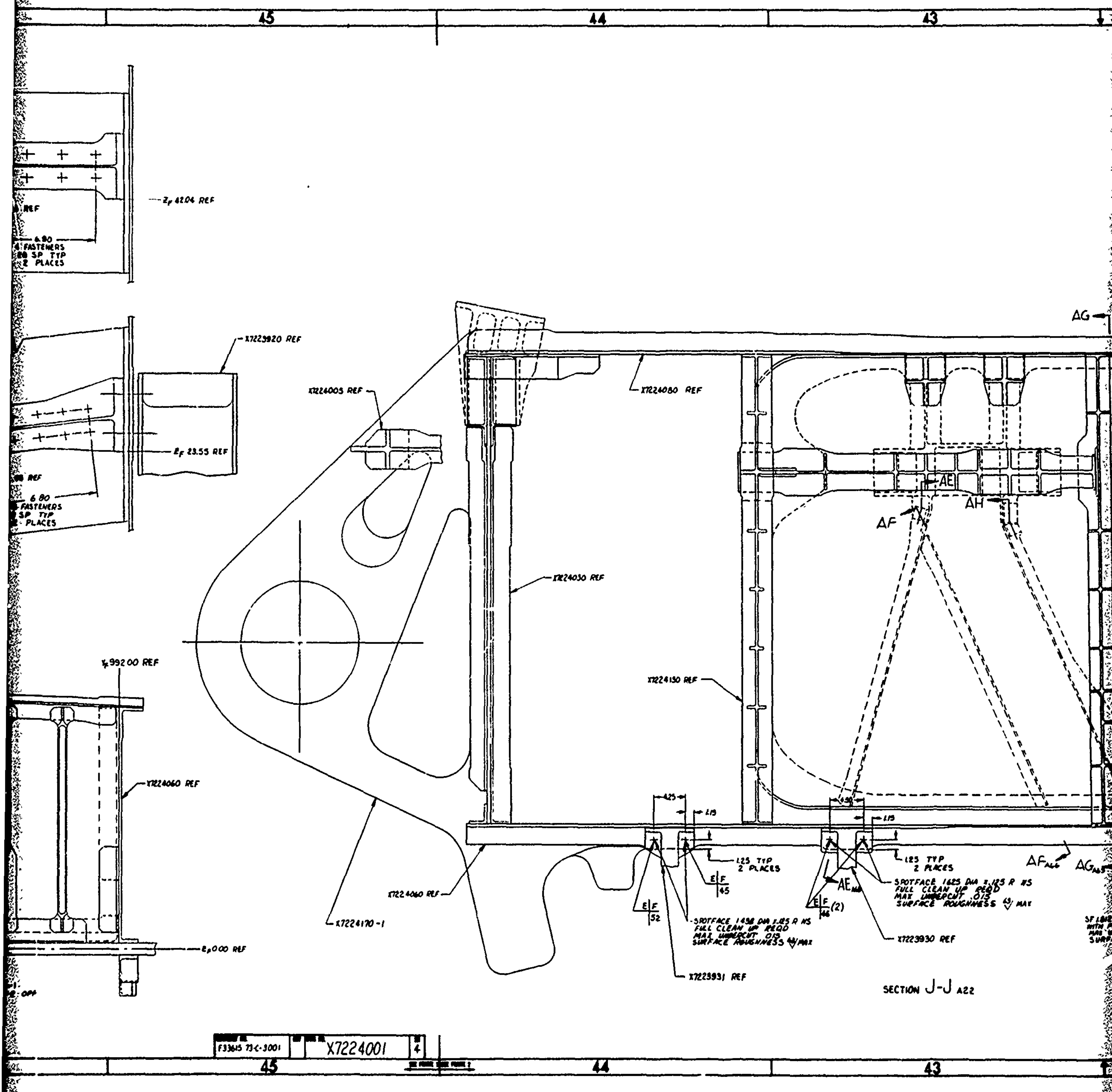

SECTION Z-Z
SCALE /2
PLACE ASSY NO. HERE (FWD SIDE)
1/2 INCH MIN SIZE LETTERS AND NUMBERS
(SEE NOTE 7)
07878 ASSY X7224001-1
X7224120 REF
X7224110 REF
X7224114 REF
X7224080-1
SECTION B-B
X7224001

Figure 2.1.1-3



48
47
46
D
C
B
A
X7224114 REF
X7224110 REF
.75 TYP
.95 REF
.95 TYP
6.90
4 FASTENERS
EQ SP TYP
2 PLACES
5 FASTENERS
EQ SP TYP
8 PLACES
.3770
.3730 HOLE (56)
81755/C020-12-18(56) HEAD LGTH OPT
81755/C2950-12(56)
X7223991-12(56) UNDER HEAD
TORQUE PER 81755/M016-6A
SECTION M-M D26
SCALE 1/2
Z_F 4.99 REF
6.60
6.80
5 FASTENERS
.3770
.3730 HOLE (58)
81755/C020-12-19(58) HEAD LGTH OPT
81755/C2950-12(58)
X7223991-12(58) UNDER HEAD
TORQUE PER 81755/M016-6A
SECTION N-N D24
SCALE 1/2
℄ 992.00 REF
X7224010 REF
X7224080 REF
X7224170 REF
X7224030-1
X7224030-2 OPP
SECTION F-F A25
ROTATED 7° CW



45
44
43
Z_F 42.04 REF
6.80
4 FASTENERS
SP TYP
2 PLACES
X7223920 REF
X7224005 REF
X7224080 REF
Z_F 23.55 REF
X7224030 REF
X7224150 REF
Y_F 992.00 REF
Y7224060 REF
X7224060 REF
X7224170-1
Z_F 0.00 REF
AG
AE
AH
AF
1.25 TYP
2 PLACES
SPOTFACE 1.625 DIA x .125 R HS
FULL CLEAN UP REQD
MAX UNDERCUT .015
SURFACE ROUGHNESS 63 MAX
SPOTFACE 1.438 DIA x .125 R HS
FULL CLEAN UP REQD
MAX UNDERCUT .015
SURFACE ROUGHNESS 63 MAX
X7223930 REF
X7223931 REF
SECTION J-J A22
F33615 73-C-3001
X7224001
4

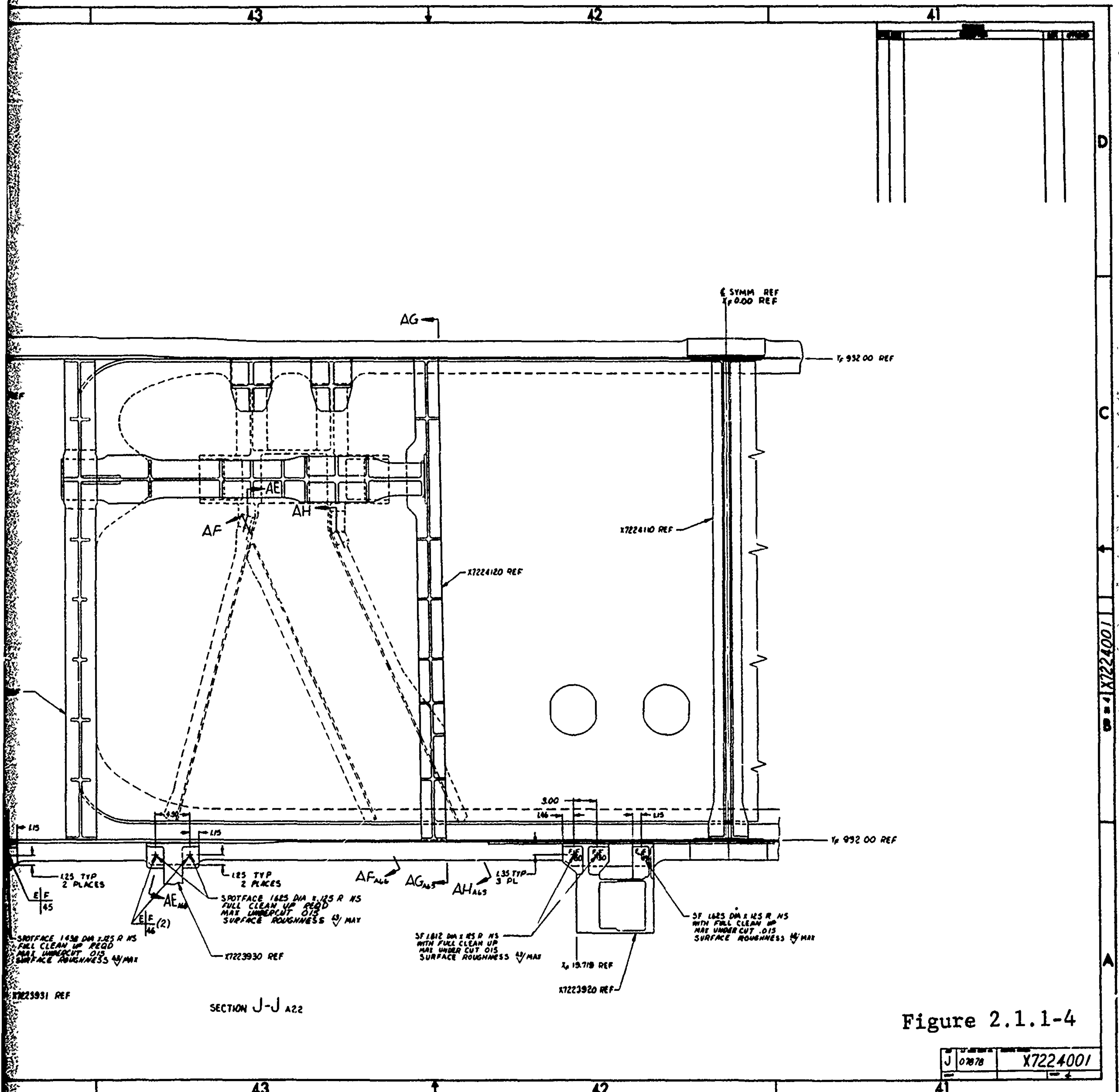
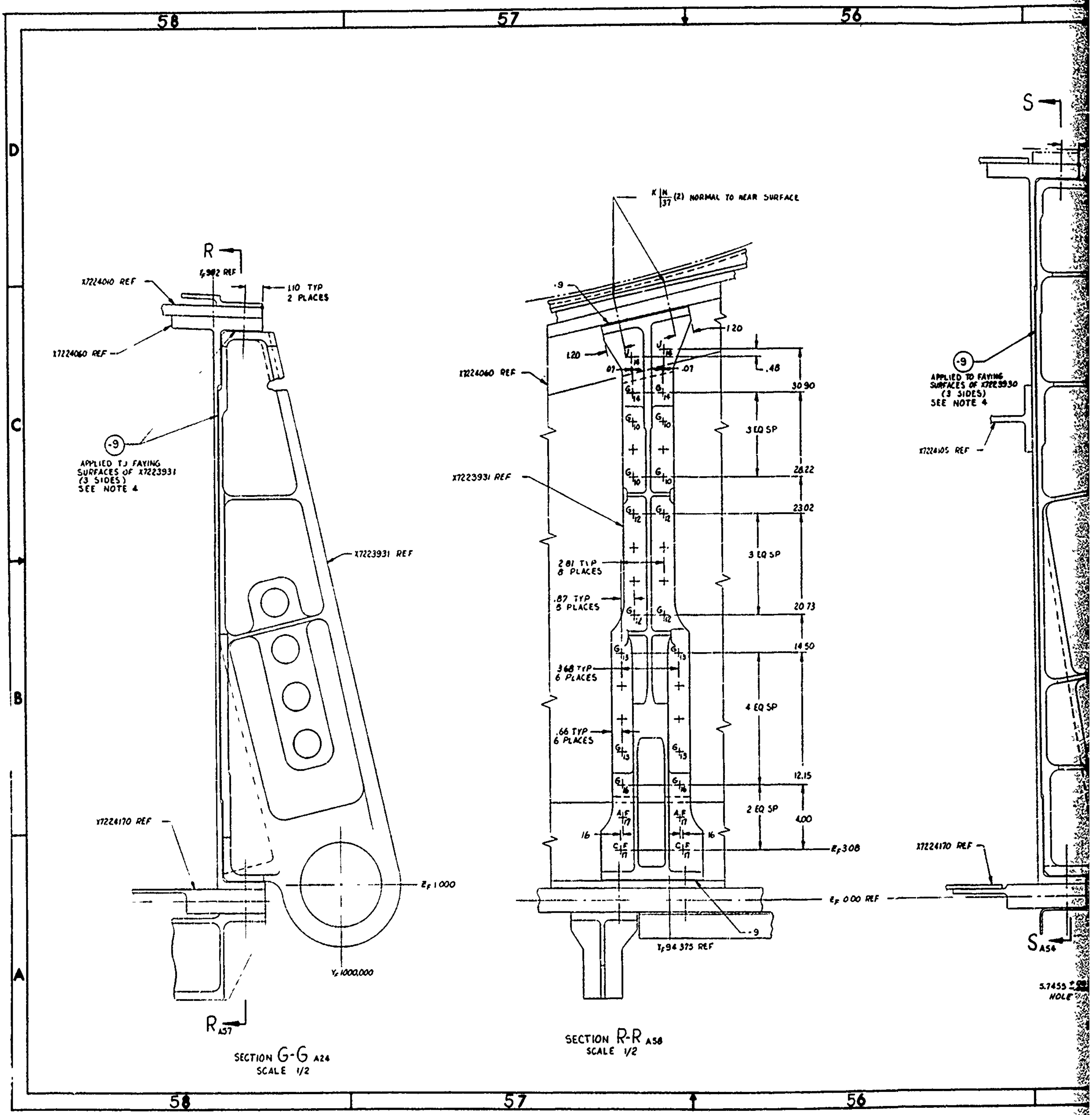


Figure 2.1.1-4

3



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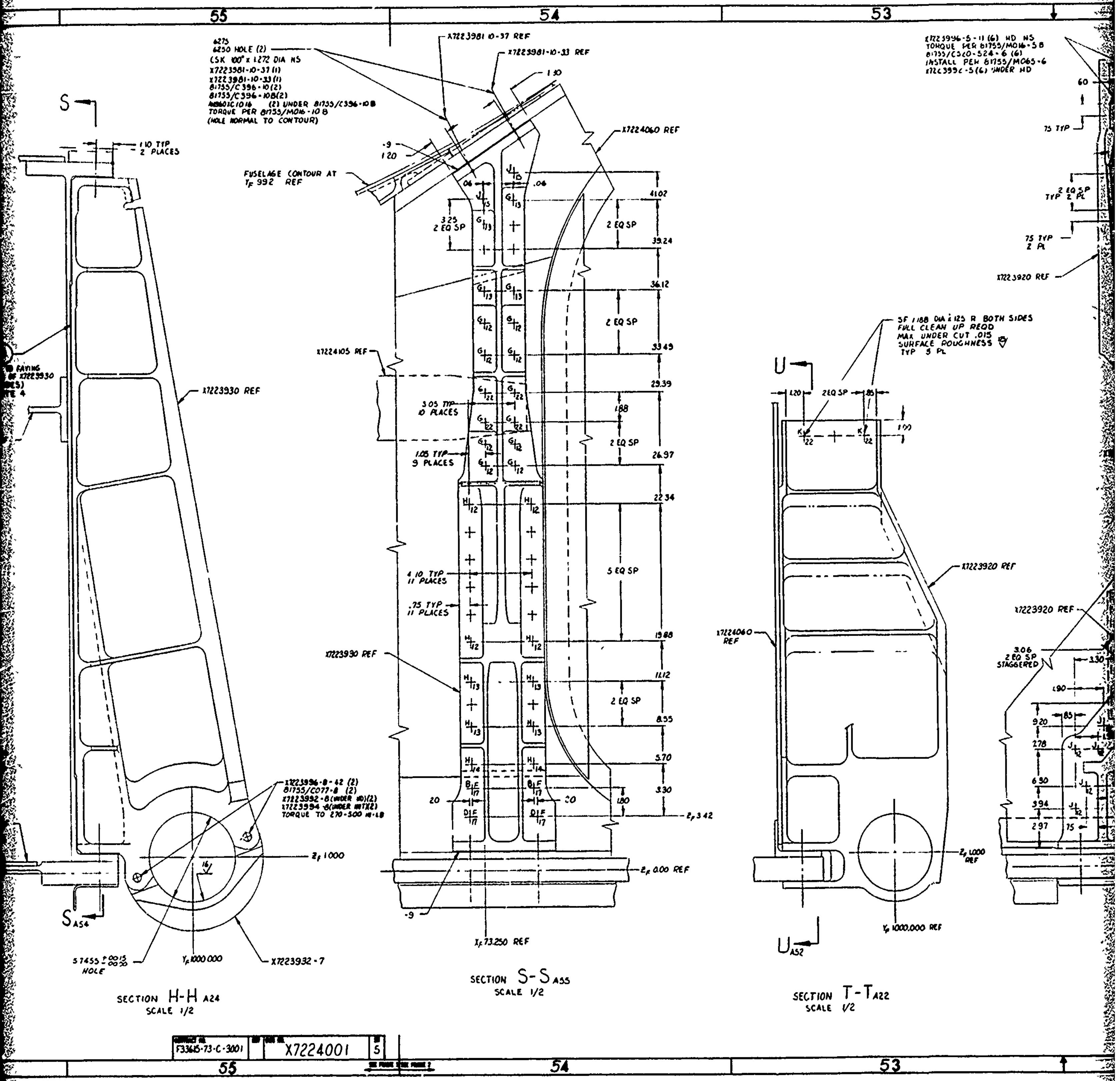
SECTION R-R A58
SCALE 1/2



55
54
53
SECTION H-H A24
SCALE 1/2
SECTION S-S A55
SCALE 1/2
SECTION T-T A22
SCALE 1/2
X7223930 REF
X7223932-7
Y_F 1000.000
FUSELAGE CONTOUR AT Y_F 992 REF
X7224060 REF
X7224105 REF
X7223981-10-37 REF
X7223981-10-33 REF
X7223920 REF
Z_F 1000
Z_F 0.00 REF
X_F 73.250 REF
Y_F 1000.000 REF
2 EQ SP
5 EQ SP
3.05 TYP 10 PLACES
1.05 TYP 9 PLACES
4.10 TYP 11 PLACES
.75 TYP 11 PLACES
SF .188 DIA & .125 R BOTH SIDES
FULL CLEAN UP REQD
MAX UNDER CUT .015
SURFACE ROUGHNESS
TYP 5 PL
F33615-73-C-3001
X7224001
5

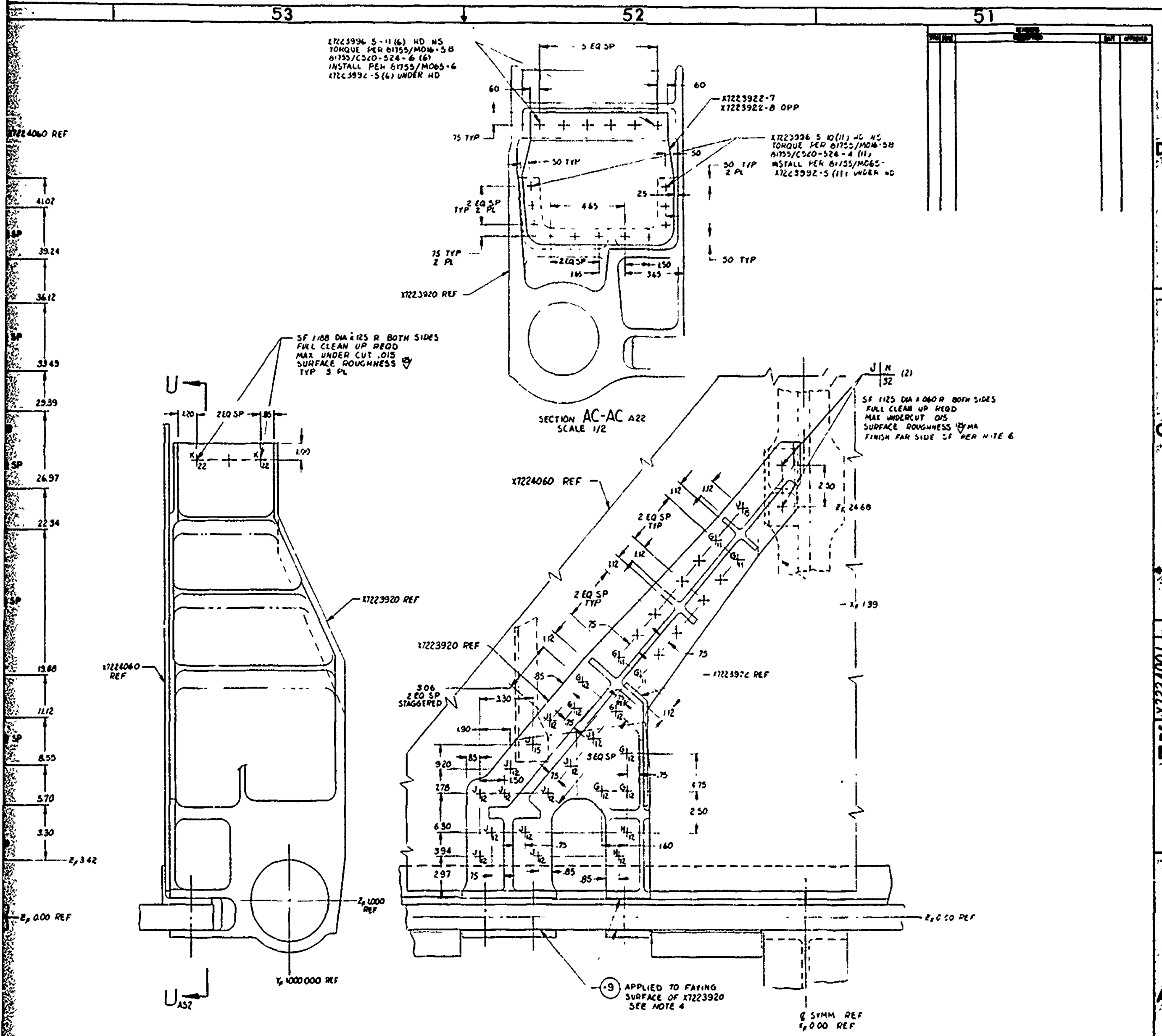
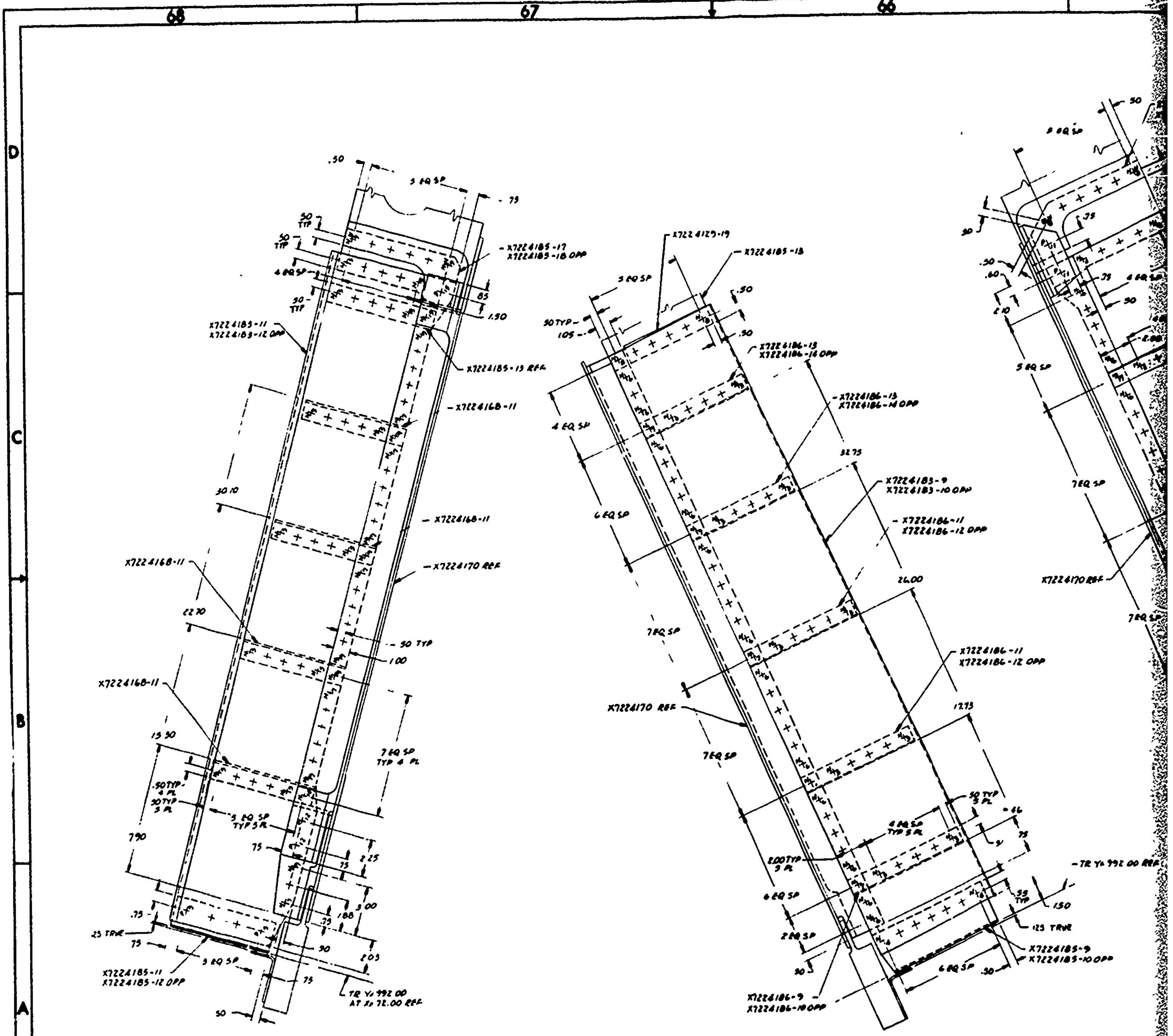


Figure 2.1.1-5

3



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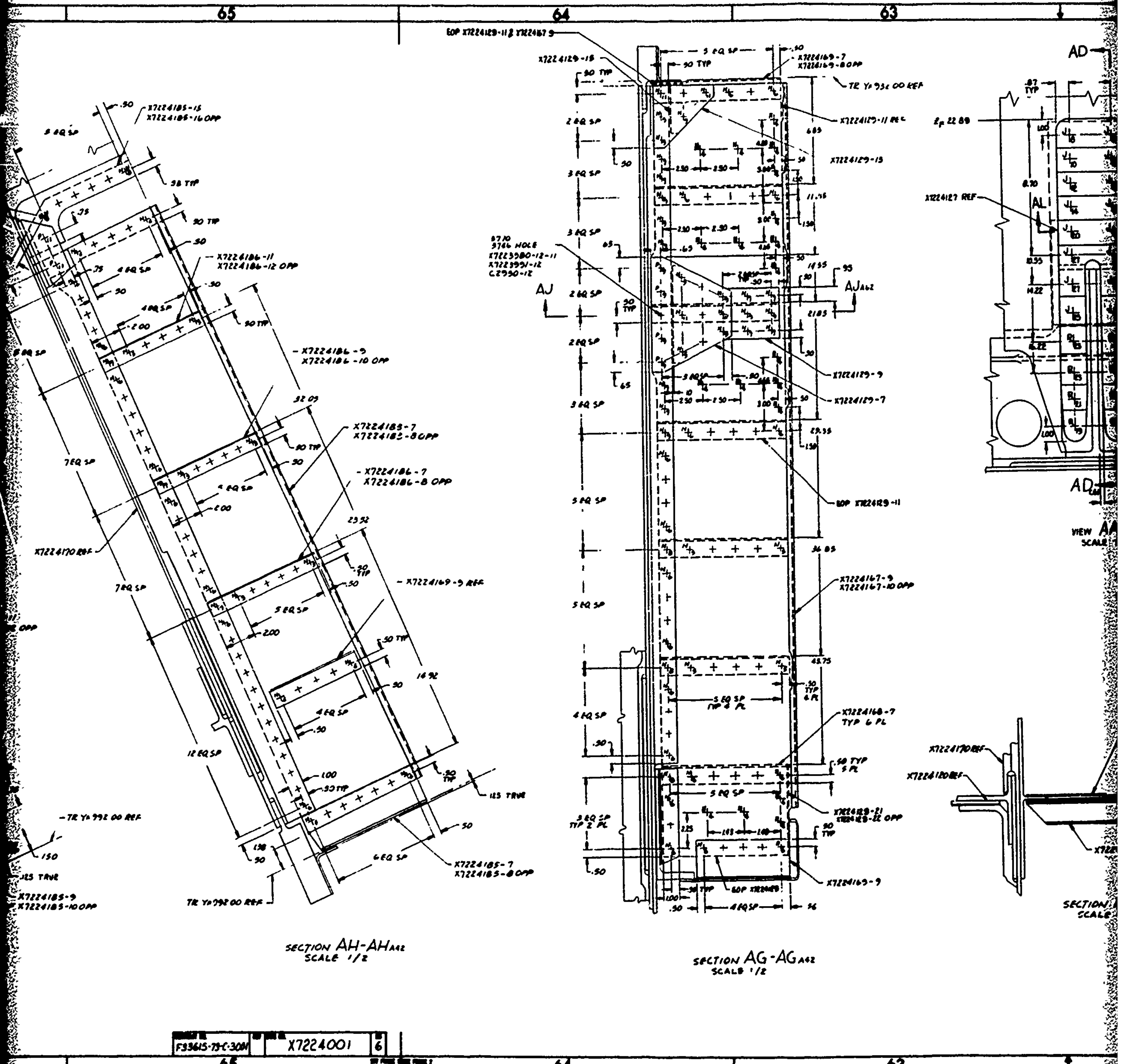
SECTION AF-AF A43
SCALE 1/2



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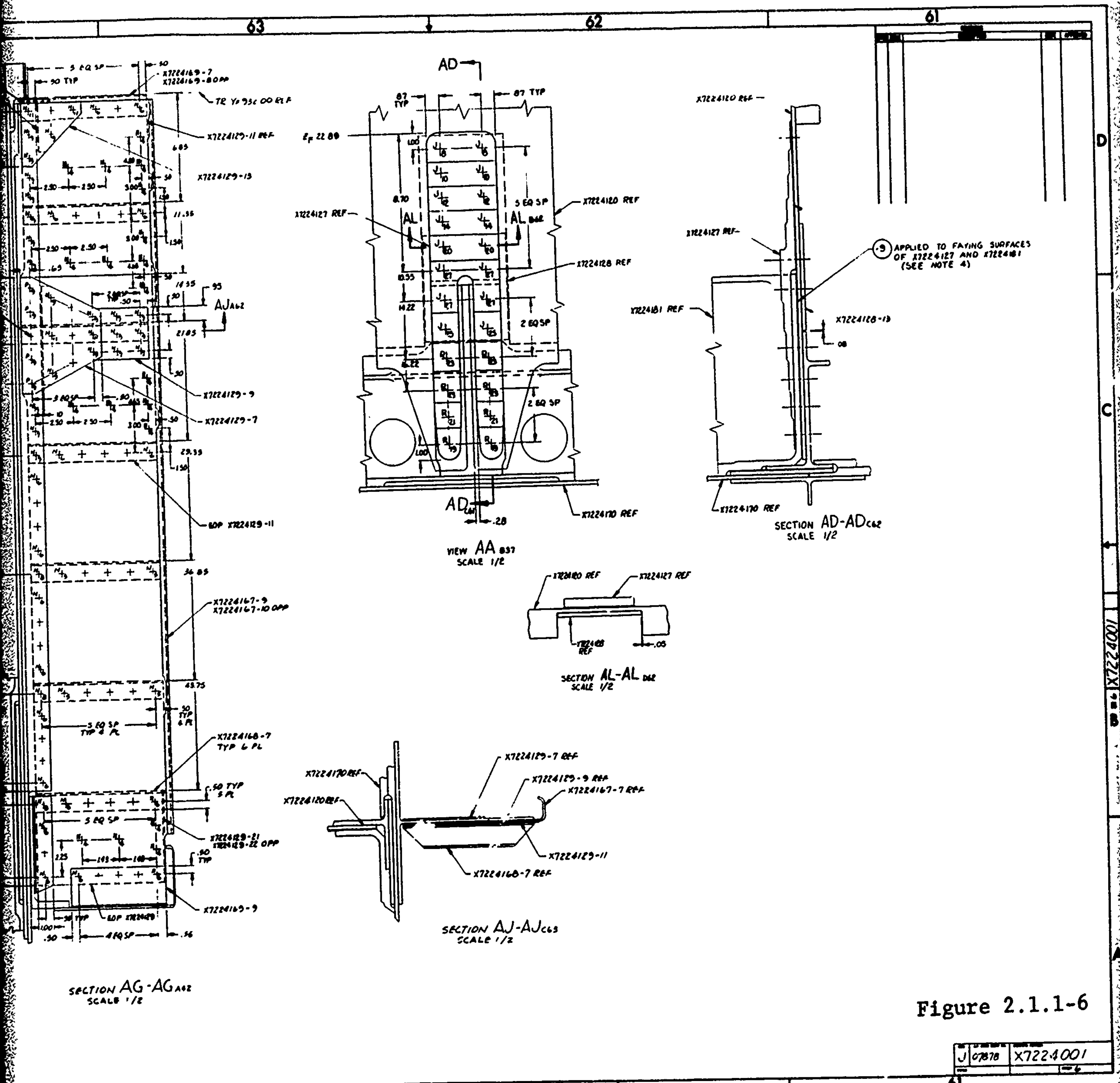
SECTION AG-AG A42
SCALE 1/2

F33615-73-C-3081	X7224001	6

2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SCALE 1/2
VIEW AA B37
SCALE 1/2
SECTION AD-AD C62
SCALE 1/2
SECTION AL-AL B62
SCALE 1/2
SECTION AJ-AJ C63
SCALE 1/2
X7224001

Figure 2.1.1-6

2.1.1.2 Main Landing Gear and Wing Sweep Actuator Fittings

All Main Landing Gear and the wing sweep actuator support fittings are machined beta processed 6Al-4V titanium. The Main Landing Gear drag strut and side brace fittings employ EB welding of machined details.

These fittings are shown in the following figures:

X7223901	Wing sweep actuator fitting detail	Figure 2.1.1-7
3950	Wing sweep actuator fitting assy.	Figure 2.1.1-8
3920	MLG side brace fitting assy.	Figure 2.1.1-9
3930	MLG trunnion X_F72	Figure 2.1.1-10
3932	MLG trunnion cap X_F72	Figure 2.1.1-11
3931	MLG trunnion $X_F95.5$	Figure 2.1.1-12
3941	MLG drag strut fitting	Figure 2.1.1-13

2.1.2 Structural Analysis

2.1.2.1 General

During the reporting period the following principal structural tasks were completed or were in work:

1. Updated analysis of the sweep actuator support structure and the closure rib to reflect the effects of frictional resistance to wing sweeping.

2. Assisted in identifying areas where potential weight savings could be made and performed the necessary analysis to assure that structural integrity was maintained when designs were changed.

3. Completed sufficient stress analysis to allow structural approval of all manufacturing drawings for the NBB WCTS and simulated fuselage.

4. Provided stress data for fatigue and fracture analysis.

5. Performed additional finite element analysis for local areas and component parts in order to determine more detailed stress and load distributions and/or critical buckling loads.

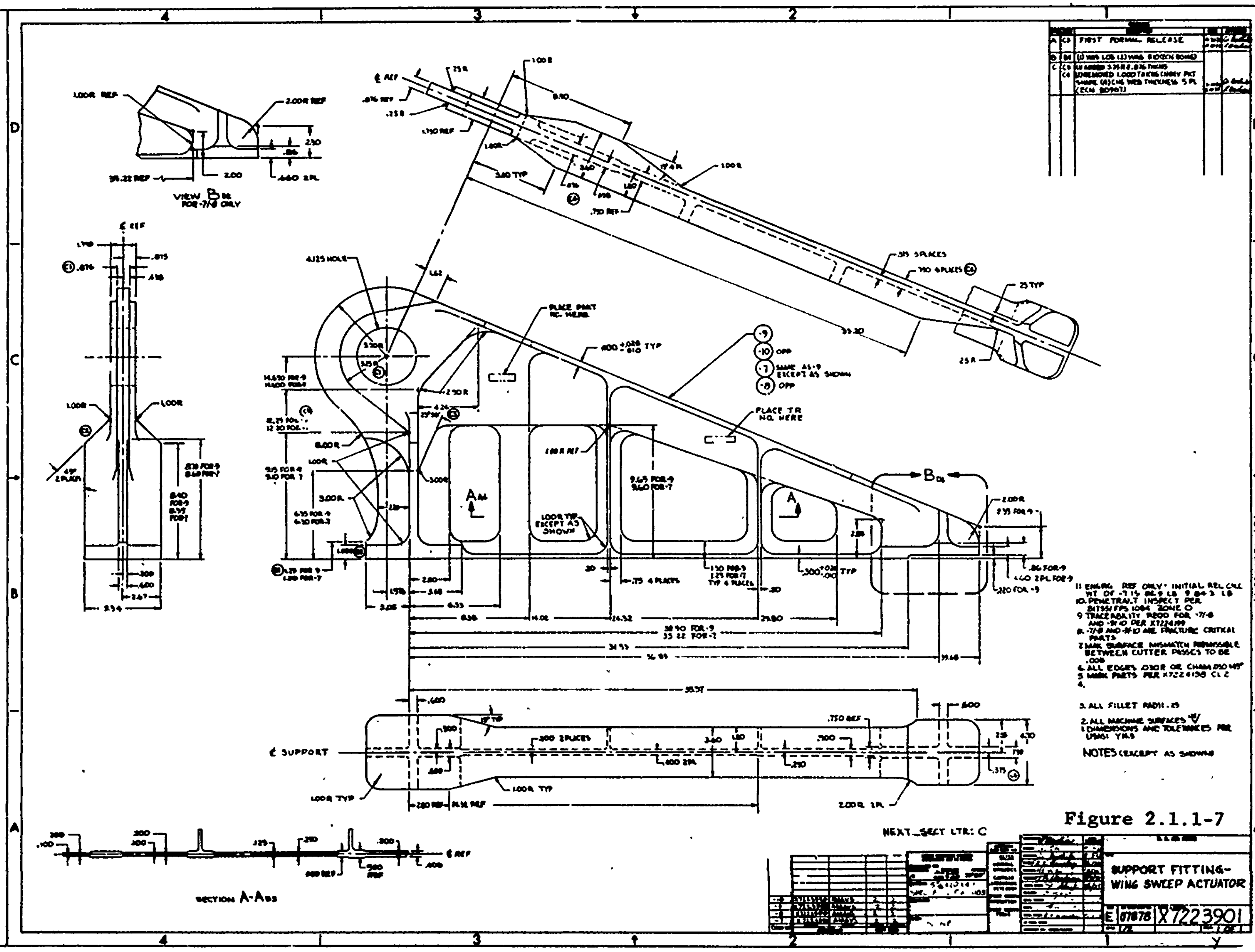
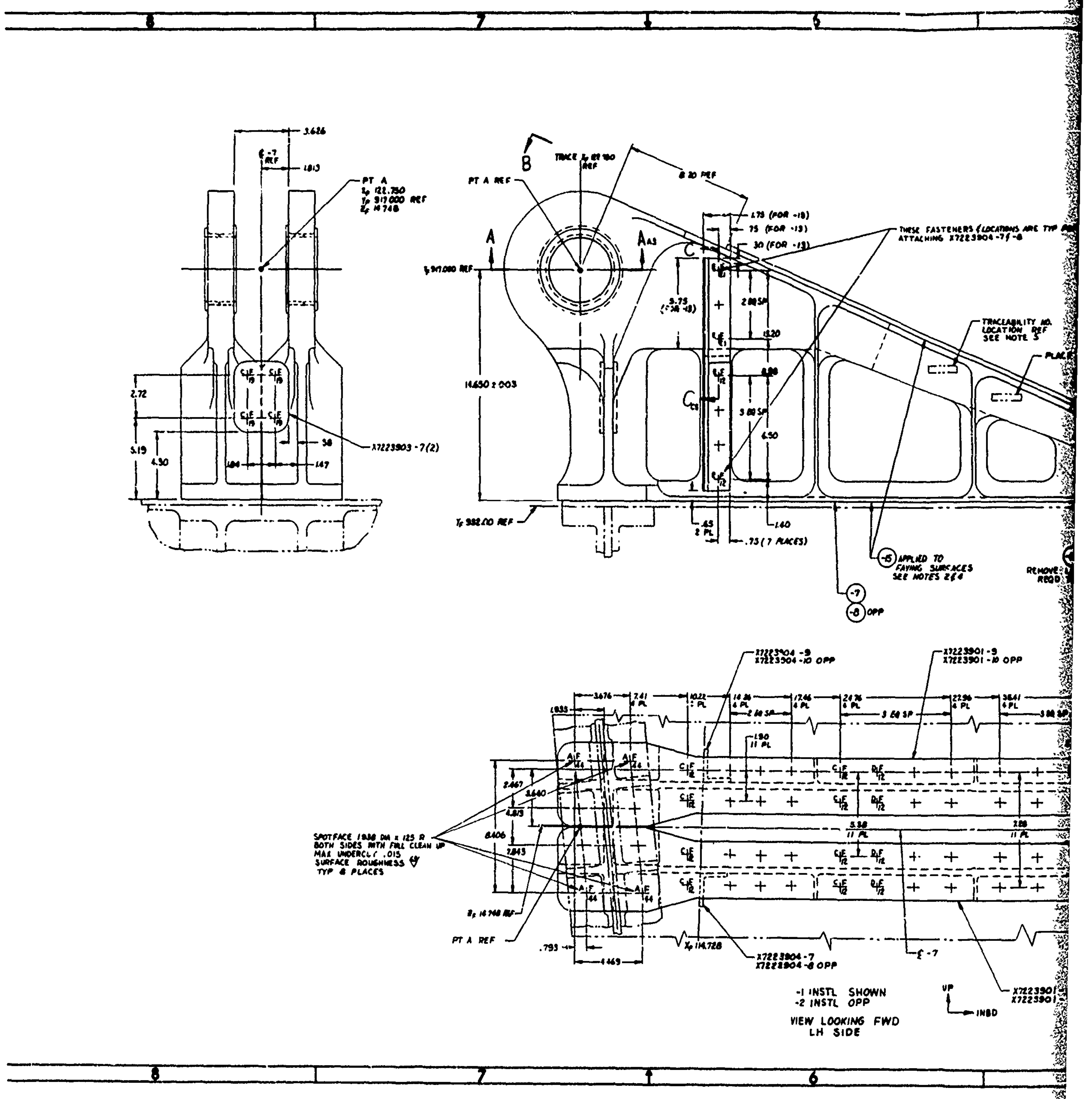
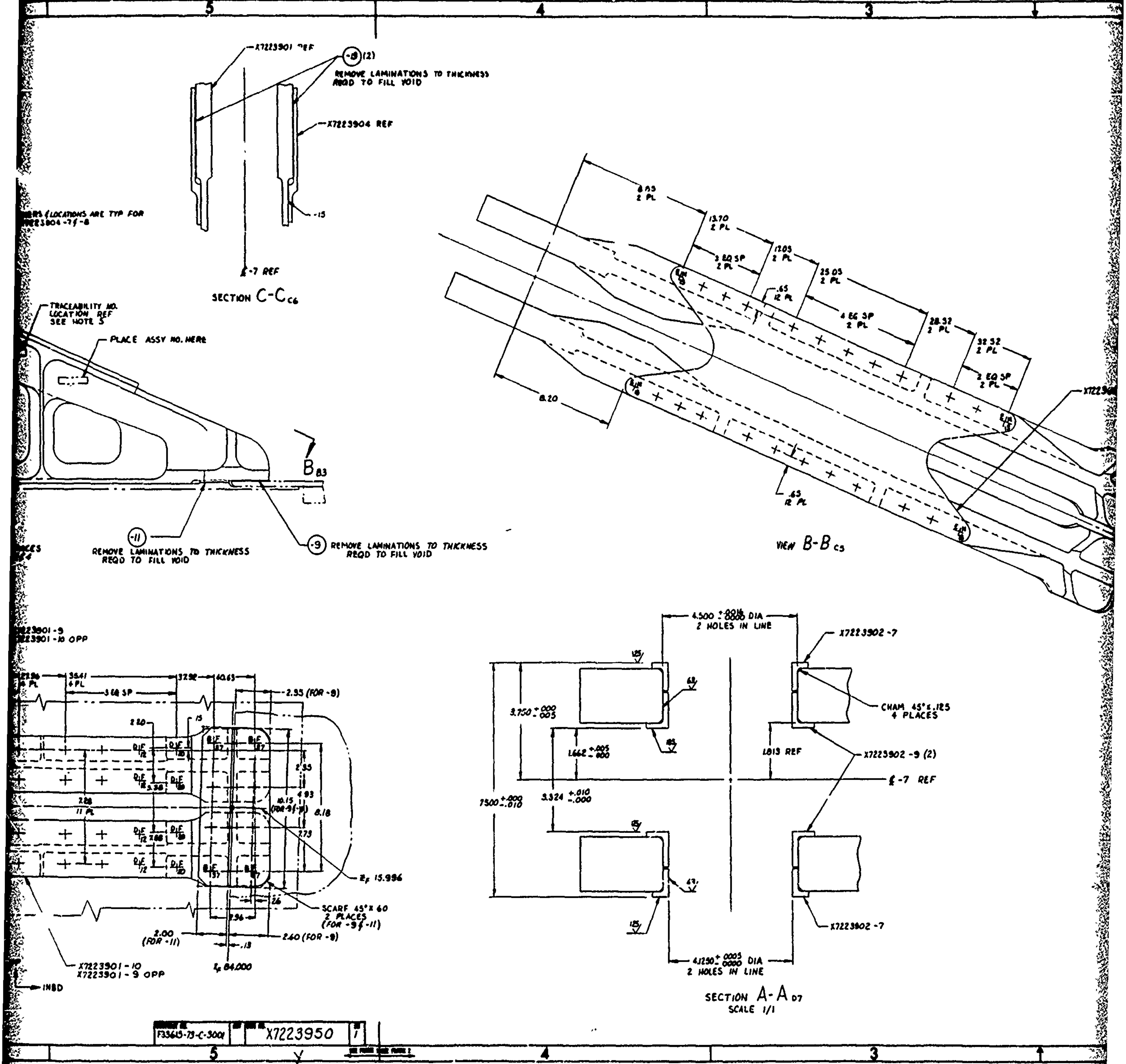
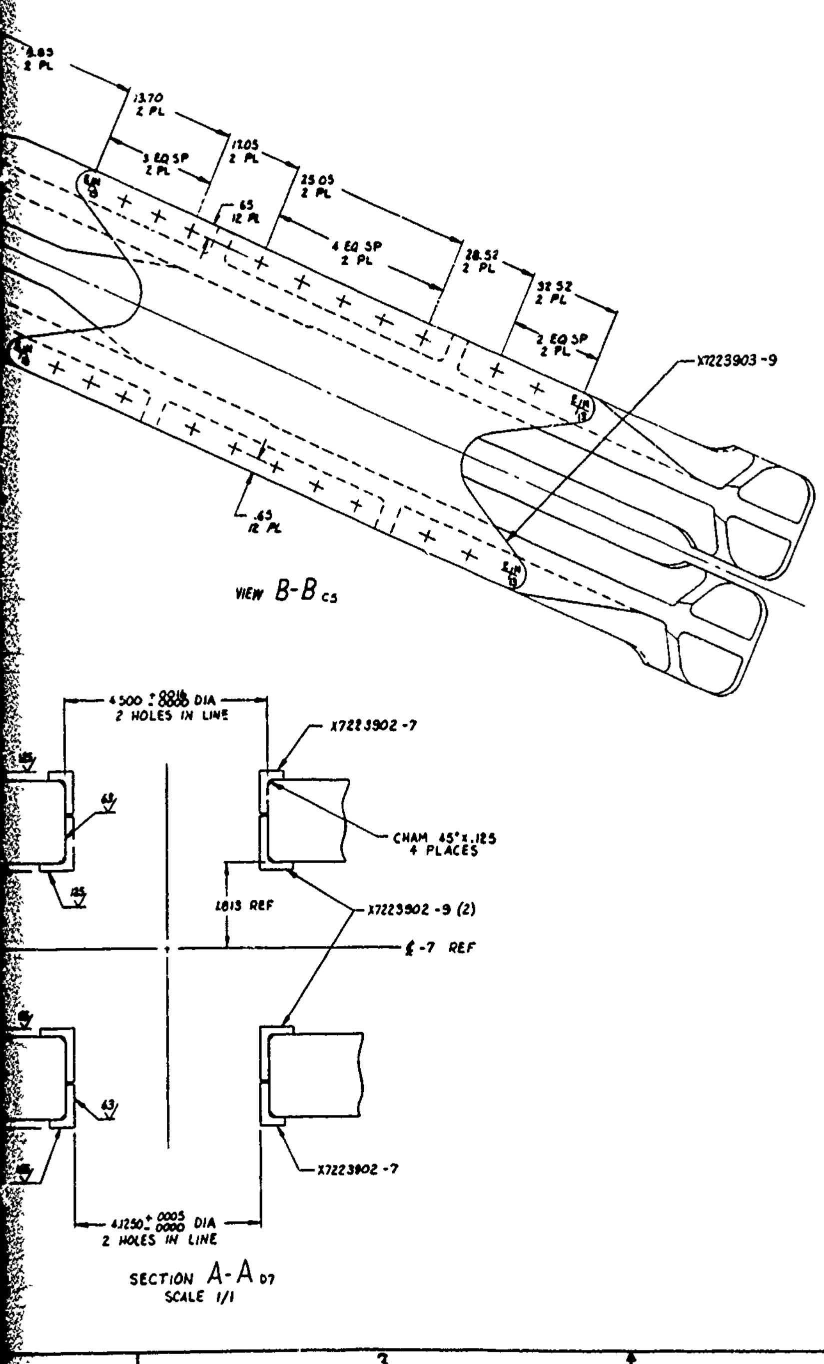

FIRST FORMAL RELEASE
VIEW B
FOR -7/8 ONLY
PLACE PART NO. HERE
PLACE TR NO. HERE
¢ SUPPORT
SECTION A-A
NEXT SECT LTR: C
NOTES (EXCEPT AS SHOWN)
3. ALL FILLET RADII .25
SUPPORT FITTING-
WING SWEEP ACTUATOR
07878
X7223901

Figure 2.1.1-7



-1 INSTL SHOWN
-2 INSTL OPP
VIEW LOOKING FWD
LH SIDE


X7223901 REF
-13 (2)
REMOVE LAMINATIONS TO THICKNESS REQD TO FILL VOID
X7223904 REF
-15
℄-7 REF
SECTION C-C C6
TRACEABILITY NO. LOCATION REF SEE NOTE 5
PLACE ASSY NO. HERE
B B3
-11
REMOVE LAMINATIONS TO THICKNESS REQD TO FILL VOID
-9
REMOVE LAMINATIONS TO THICKNESS REQD TO FILL VOID
VIEW B-B C5
8.20
4 EQ SP 2 PL
2 EQ SP 2 PL
.65 12 PL
4.500 DIA 2 HOLES IN LINE
X7223902 -7
CHAM 45° x .125 4 PLACES
1.813 REF
X7223902 -9 (2)
℄-7 REF
4.1250 DIA 2 HOLES IN LINE
SECTION A-A D7
SCALE 1/1
X7223901 -9
X7223901 -10 OPP
3.68 SP
2.35 (FOR -9)
2.60 (FOR -9)
2.00 (FOR -11)
SCARF 45° X 60 2 PLACES (FOR -9 & -11)
X7223901 - 10
X7223901 - 9 OPP
INBD
F33615-73-C-5001
X7223950
1



8. MARK ASSY PER X7224198 CLASS 2A.
7. SURFACE ROUGHNESS OF NOTED HOLES SHALL NOT EXCEED 63 IN STEEL AND TITANIUM AND 125 IN ALUMINUM

6 FASTENER CODE:

BASIC CODE — HEAD LOCATION (N) NEAR SIDE (F) FAR SIDE — GRIP LENGTH DASH NO.

BASIC CODE	HOLE DIA	FASTENER	NUT 81755/	WASHER UNDER HD	WASHER UNDER NUT	TORQUE PER 81755/M016	HOLE SURF ROUGHNESS
A	.8775 .8750	X7223995-14	C306-14	X7223988-14	X7223987-14	-14 D	63
B	.5650 .5625	X7223995-9	C306-9	X7223988-9	X7223987-9	-9 D	SEE NOTE 7
C	.5025 .5000	X7223996-8	C077-8	X7223992-8	X7223994-8	-8 B	125
D	.3770 .3750	X7223996-6	C077-6	X7223992-6	X7223994-6	-6 B	125
E	.3770 .3750	81755/C0[illegible]	C2950-12	X7223991-12	AN960PD[illegible]	-6 A	125

5. -7 & -8 CONTAIN FRACTURE CRITICAL DETAIL PARTS. RETAIN ORIGINAL MATERIAL TRACEABILITY NUMBERS IN ACCORDANCE WITH X7224199.
4 SEALING MATERIALS AND METHODS OF APPLICATION PER X7224196.
3 INSTALL ALL FASTENERS WITH -15 GENERAL SEALANT.
2. APPLY -15 GENERAL SEALANT TO ALL FAYING SURFACES.
1. DIMENSIONS AND TOLERANCES PER USASI Y14.5.

NOTES (EXCEPT AS SHOWN)

Figure 2.1.1-8

SEE SEPARATE PARTS LIST

NEXT SECTION LETTER: D

SEE PL

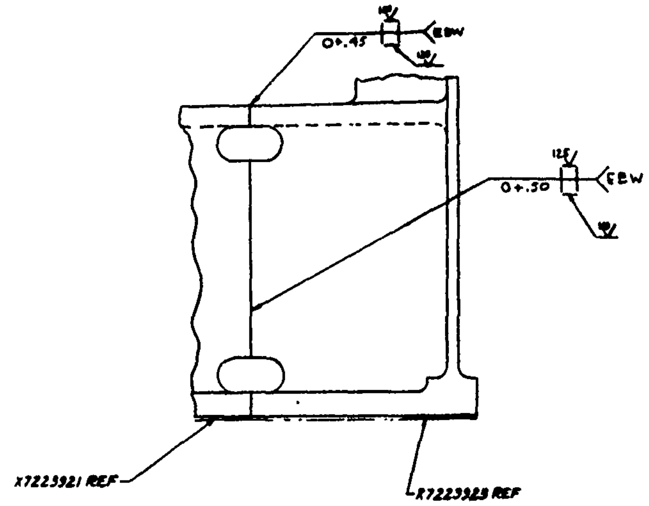
NONE

GENERAL DYNAMICS
CONVAIR AEROSPACE DIVISION
FORT WORTH OPERATION
FORT WORTH TEXAS

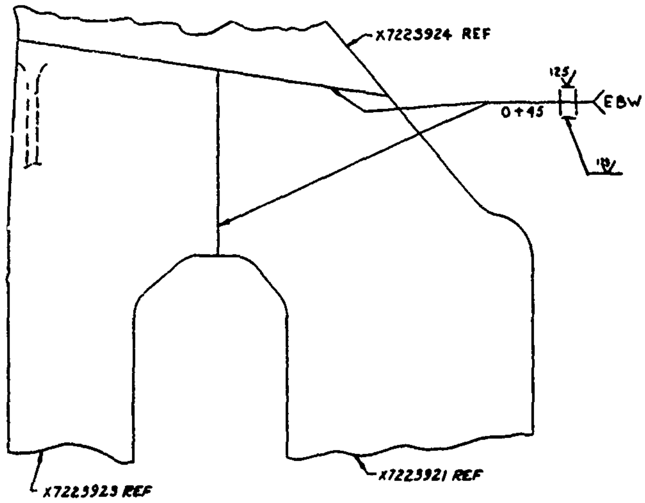
U.S. AIR FORCE

SUPPORT INSTL-
WING SWEEP
ACTUATOR

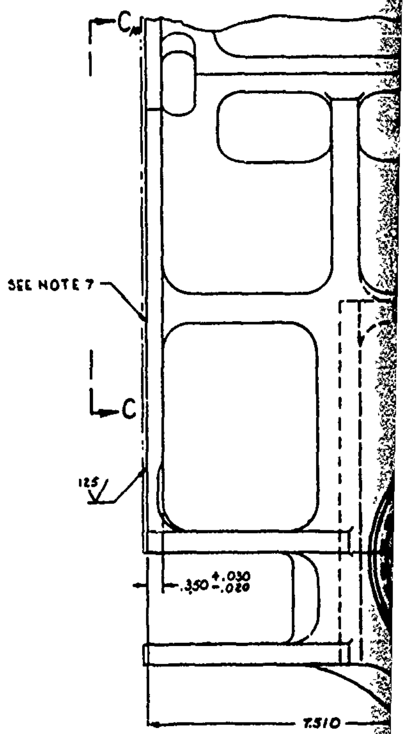
J 07878 X7223950

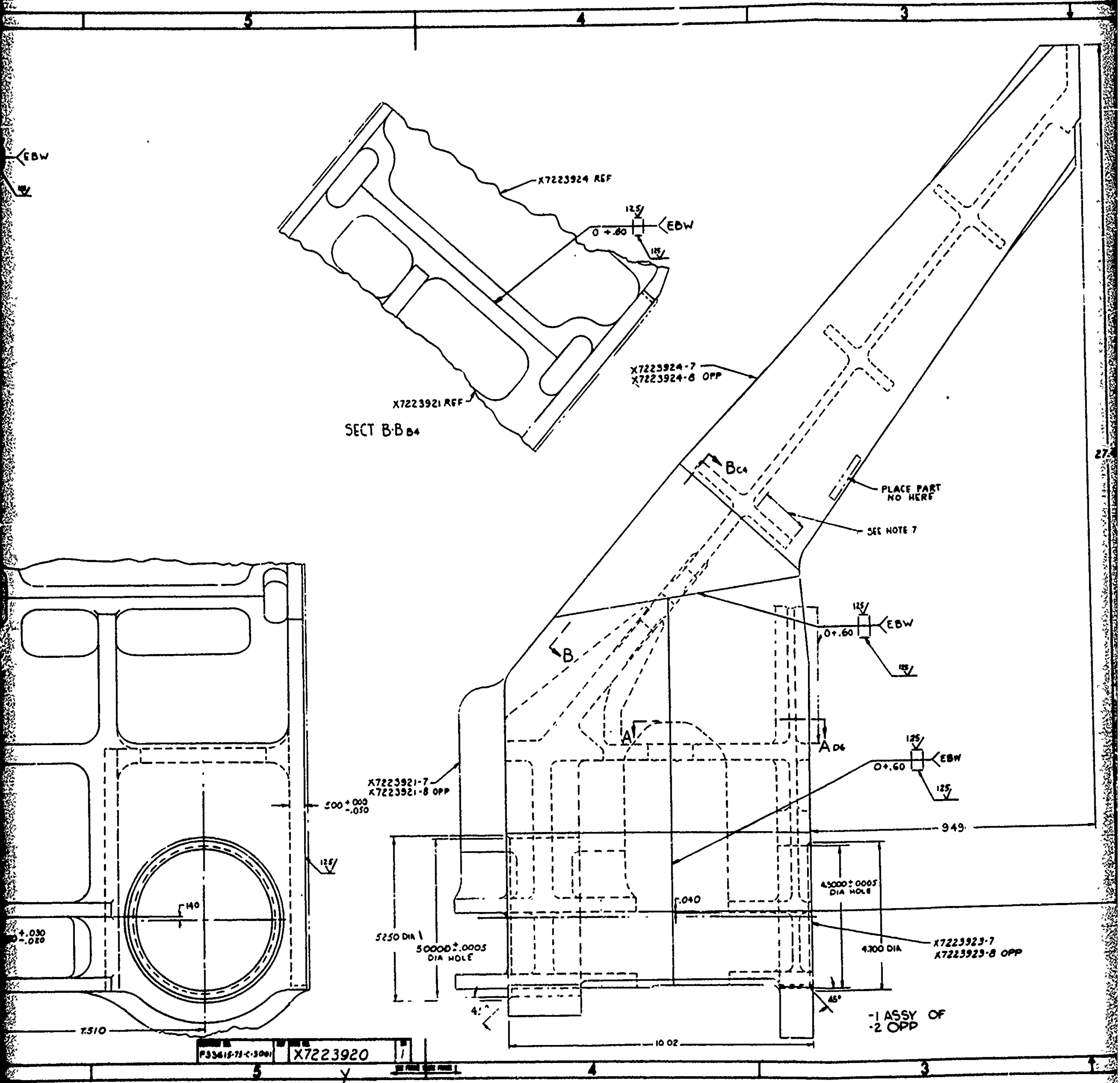


SECT. A-A B4



VIEW C-C B6




X7223924 REF
0 +.60
EBW
X7223921 REF
SECT B-B B4
X7223924-7
X7223924-8 OPP
PLACE PART NO HERE
SEE NOTE 7
X7223921-7
X7223921-8 OPP
500 +.000 -.050
.949
4.5000 ±.0005 DIA HOLE
5.250 DIA
5.0000 ±.0005 DIA HOLE
4.300 DIA
X7223923-7
X7223923-8 OPP
-1 ASSY OF -2 OPP
10.02
7.510
.140
.040
45°
F33615-73-C-5001
X7223920

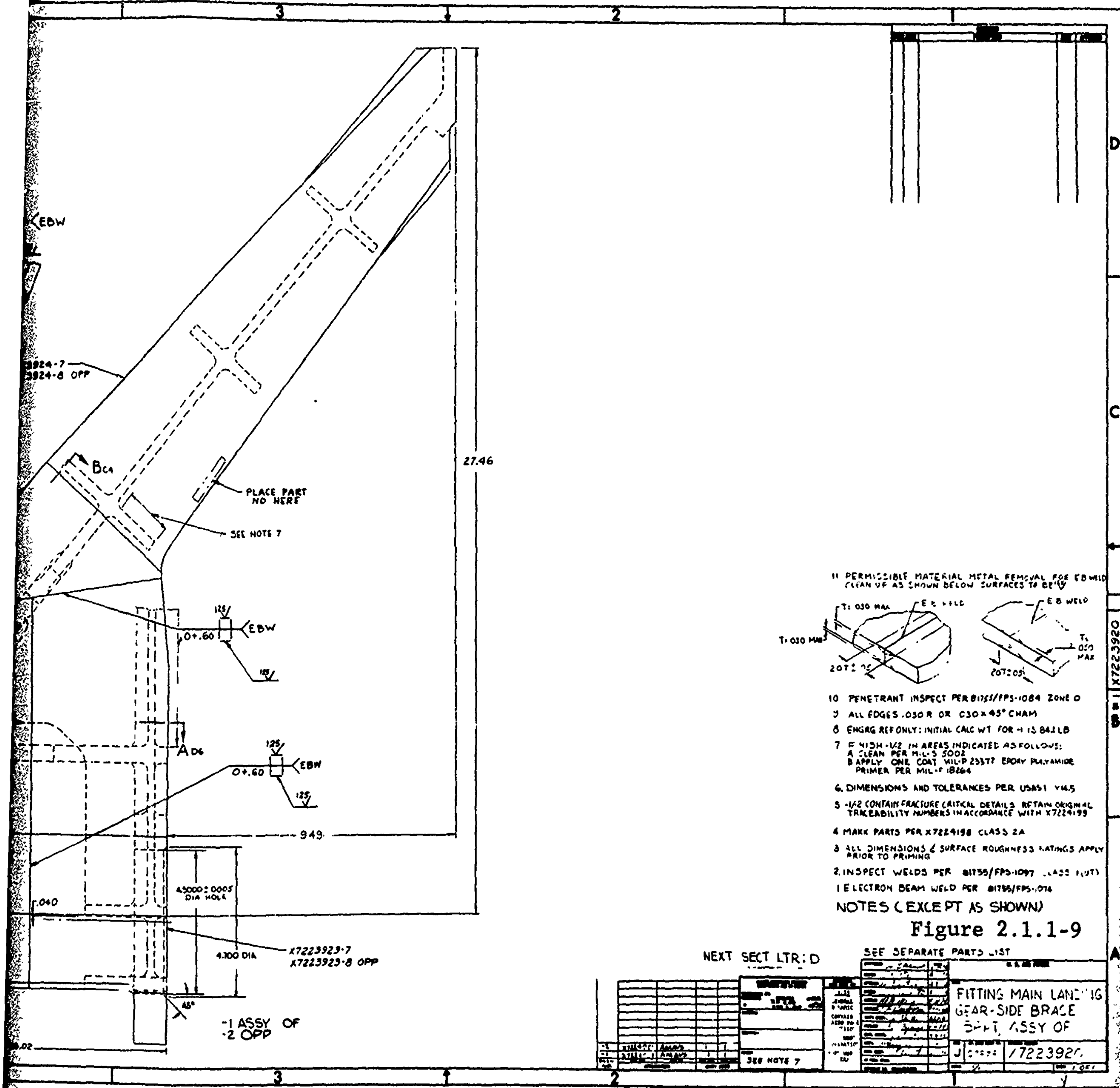


Figure 2.1.1-9

3

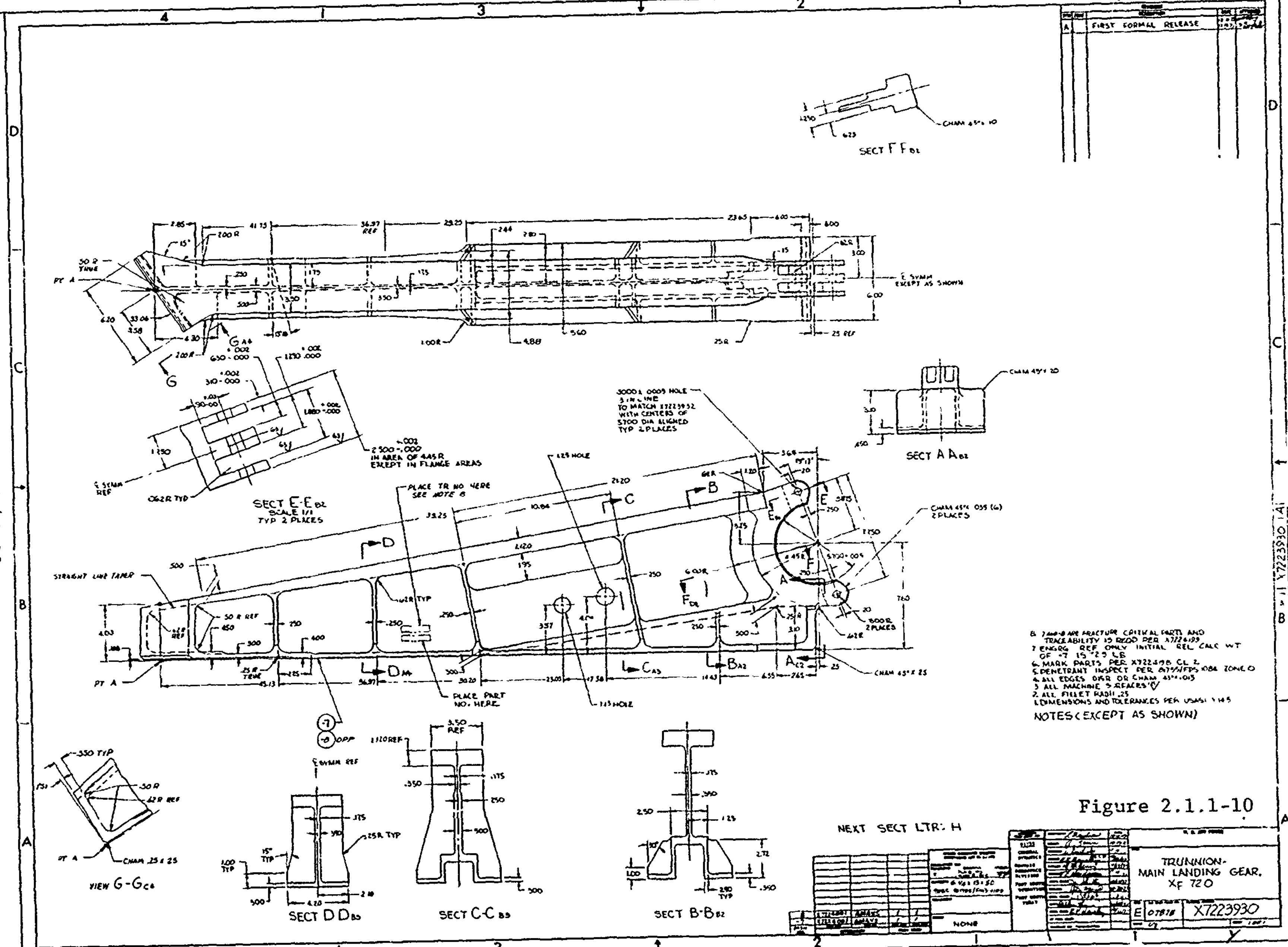
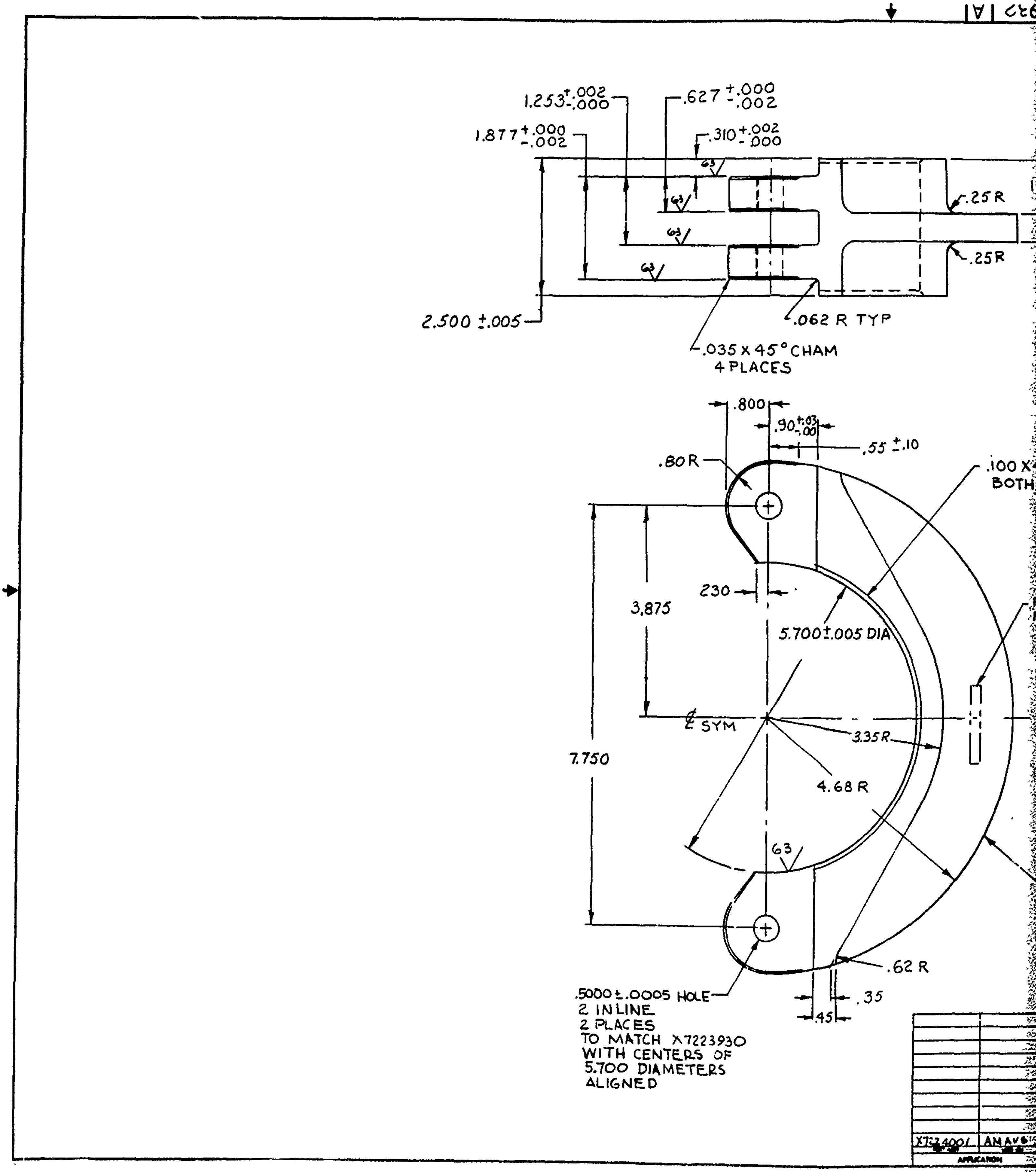
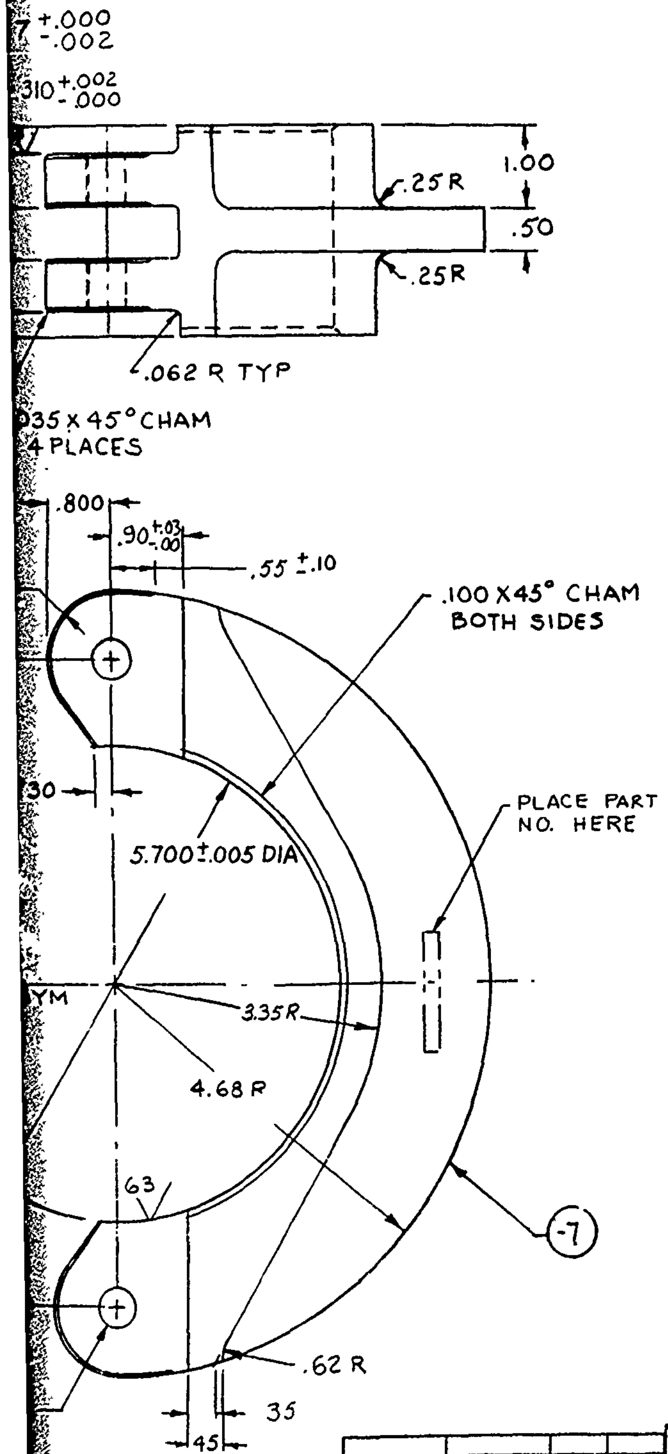


Figure 2.1.1-10



1.253 +.002 -.000
.627 +.000 -.002
1.877 +.000 -.002
.310 +.002 -.000
63
.25 R
.25 R
2.500 ±.005
.062 R TYP
.035 X 45° CHAM
4 PLACES
.800
.90 +.03 -.00
.55 ±.10
.80 R
.100 X4
BOTH
230
3,875
5.700±.005 DIA
℄ SYM
3.35 R
7.750
4.68 R
63
.62 R
.5000±.0005 HOLE
2 INLINE
2 PLACES
TO MATCH X7223930
WITH CENTERS OF
5.700 DIAMETERS
ALIGNED
.35
.45
X7234001
APPLICATION

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	FIRST FORMAL RELEASE	12-15-73 / 12-14-73	



6. ENGRG REF ONLY: INITIAL REL CALC WT OF -7 IS 7.8 LB
5. MARK PART PER X7224198 CL 2
4. PENETRANT INSPECT PER 81755/FPS-1084 ZONE O
3. ALL EDGES .015 R OR .015 X 45° CHAM
2. 125 ON ALL MACHINED SURFACES
1. DIMENSIONS & TOLERANCES PER USASI Y14.5

NOTES (EXCEPT AS SHOWN)

Figure 2.1.1-11

X7224001	ANAVS	2	2
NEXT ASSY	USED ON	QNTY REQD	

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON FRACTIONS ± ; DECIMALS XX = ±.03, XXX = ±.010 ; ANGLES ±0°30'

MATERIAL: 2 3/4 X 7 X 10 81755/FMS-1109

TREATMENT

FINISH: NONE

ADDITIONAL CODE IDENT NO. 81755

GENERAL DYNAMICS
CONVAIR AEROSPACE DIVISION
FORT WORTH OPERATION
FORT WORTH TEXAS

U. S. AIR FORCE

TITLE: CAP, TRUNNION-MLG, XF 72

SIZE D | CODE IDENT NO. 07878 | DRAWING NUMBER X7223932

SCALE 1/1 2-23 / 2-24 SHEET 1 OF 1

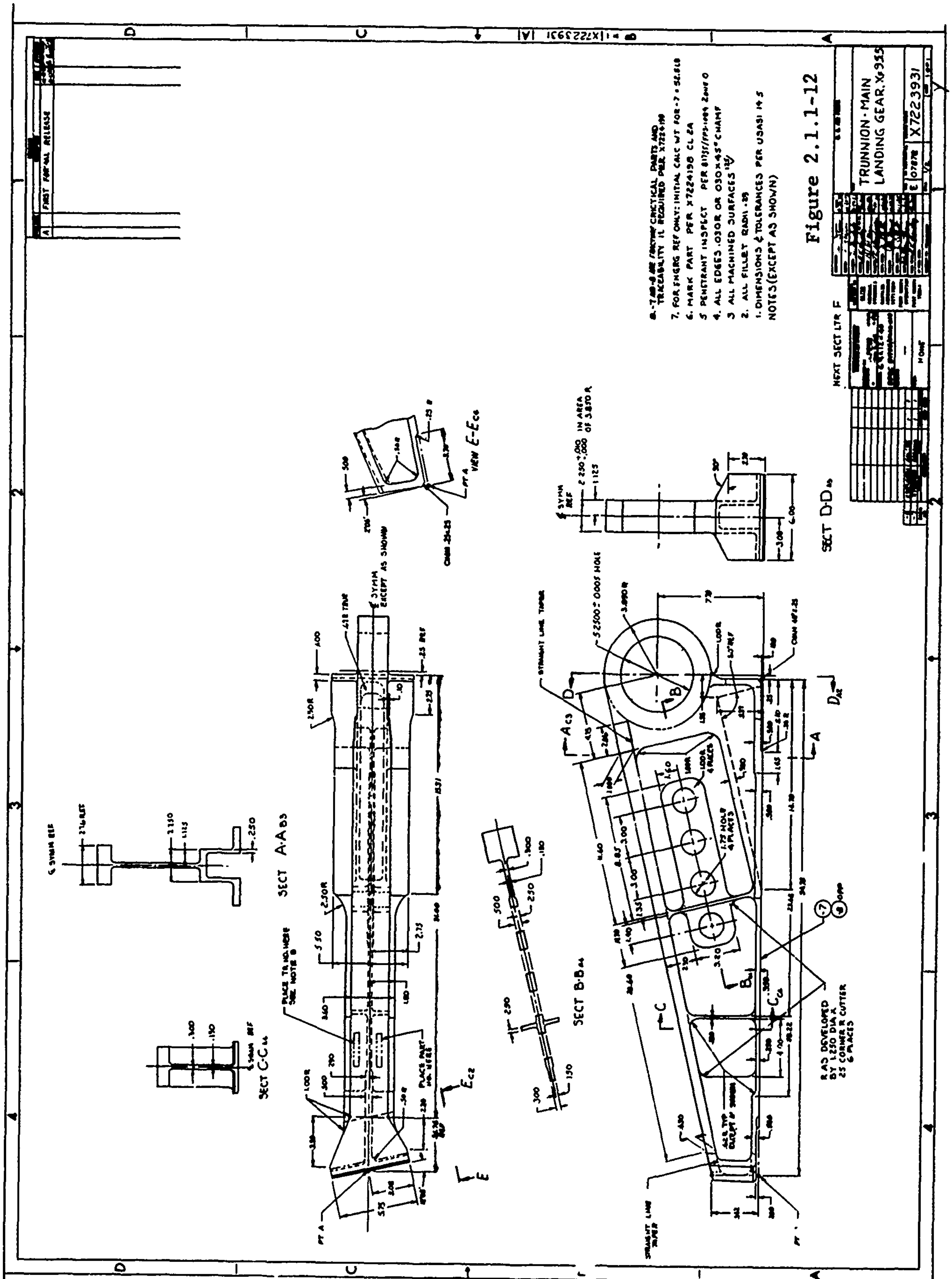
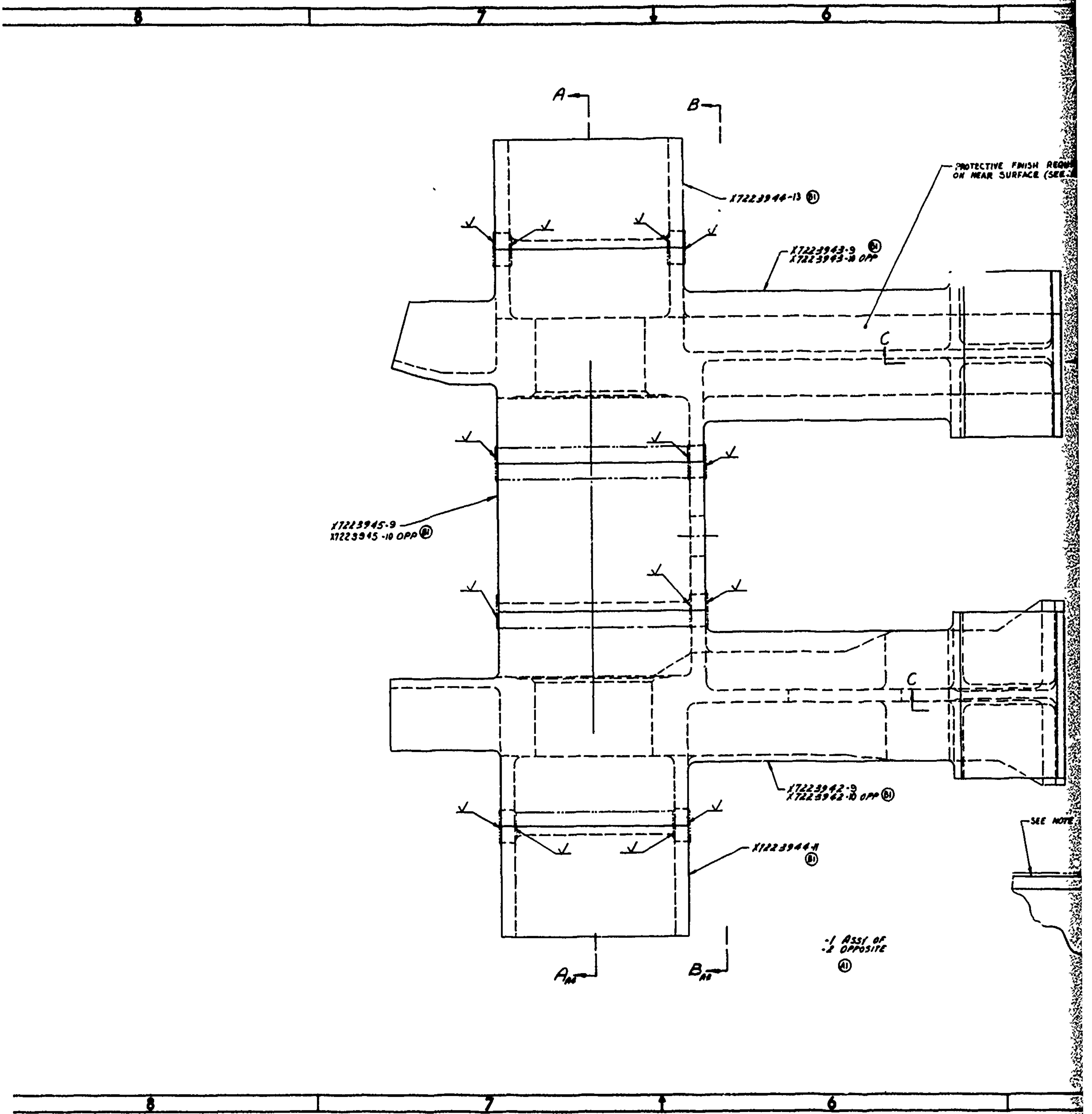
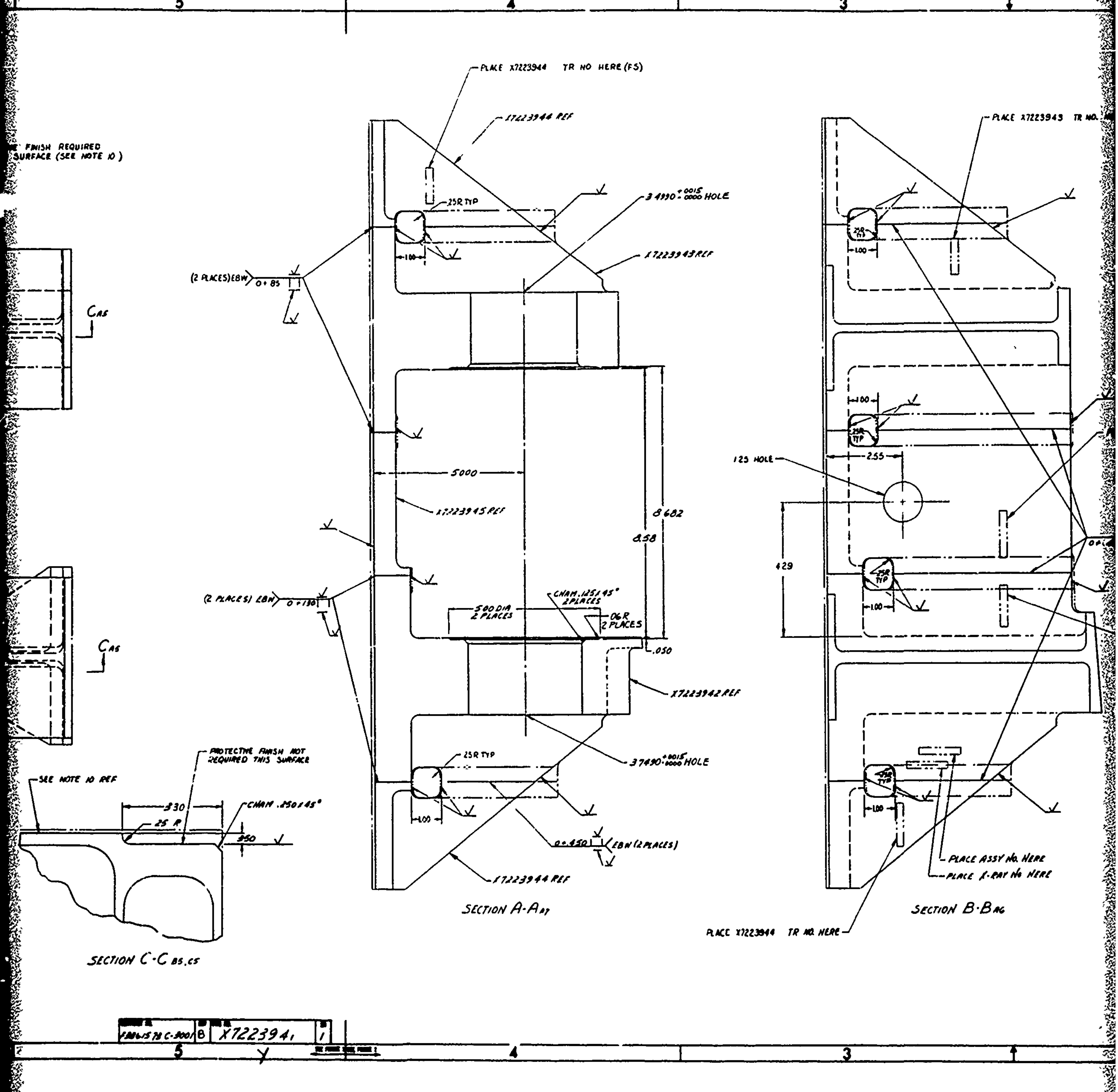


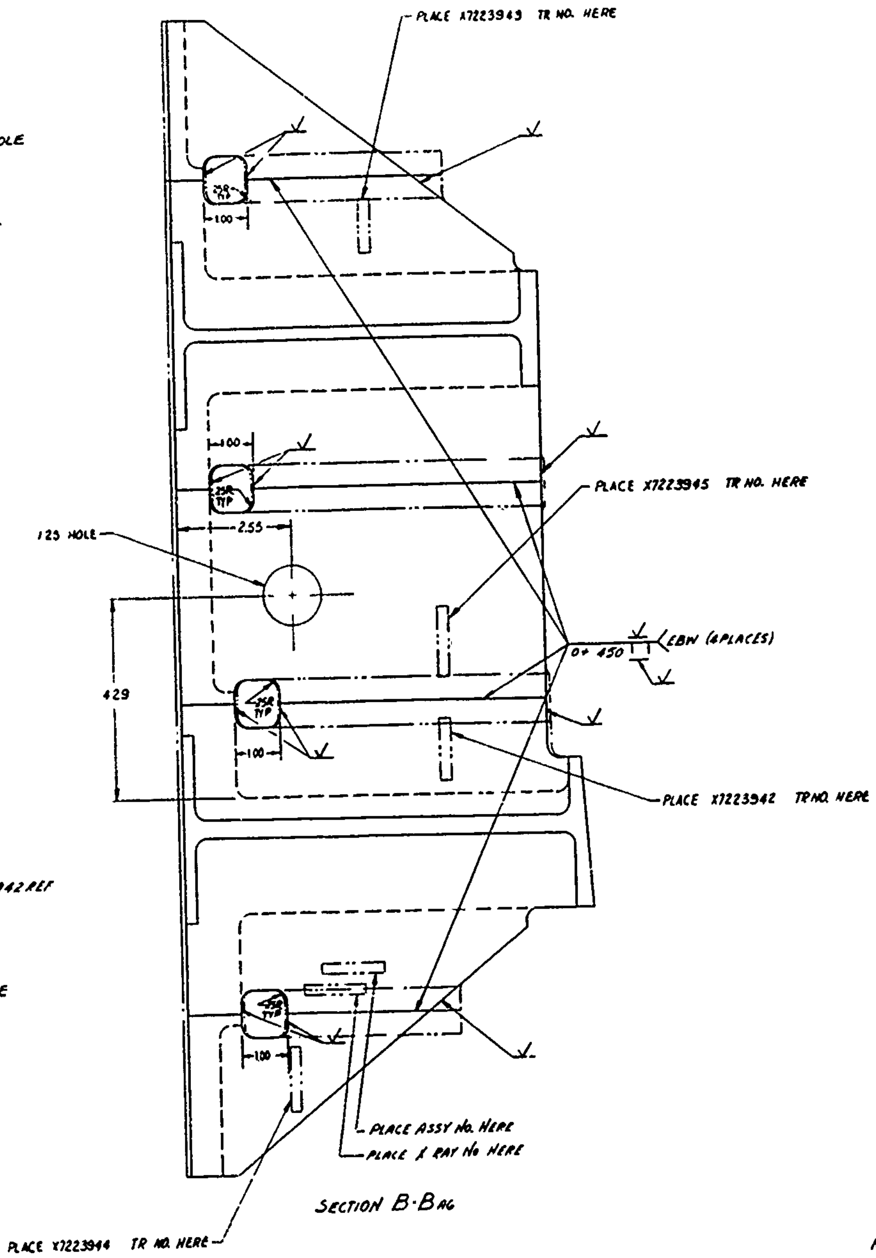
Figure 2.1.1-12



8
7
6
A
B
X7223944-13 B1
PROTECTIVE FINISH REQU
ON NEAR SURFACE (SEE
X7223943-9 B1
X7223943-10 OPP
C
X7223945-9
X7223945-10 OPP B1
C
X7223942-9
X7223942-10 OPP B1
SEE NOTE
X7223944-11
B1
-1 ASSY OF
-2 OPPOSITE
A1
A
B
8
7
6


PLACE X7223944 TR NO HERE (FS)
X7223944 REF
FINISH REQUIRED SURFACE (SEE NOTE 10)
.25R TYP
3.4990 +.0015 -.0000 HOLE
X7223943 REF
(2 PLACES) EBW 0+.85
1.00
5.000
X7223945 REF
8.682
8.58
CHAM .125 X 45° 2 PLACES
5.00 DIA 2 PLACES
.06R 2 PLACES
.050
X7223942 REF
3.7490 +.0015 -.0000 HOLE
(2 PLACES) EBW 0+.130
0+.450 EBW (2 PLACES)
SECTION A-A
PLACE X7223943 TR NO.
.125 HOLE
2.55
4.29
PLACE ASSY No. HERE
PLACE X-RAY No HERE
SECTION B-B
PLACE X7223944 TR NO. HERE
PROTECTIVE FINISH NOT REQUIRED THIS SURFACE
SEE NOTE 10 REF
3.30
.25 R
CHAM .250 X 45°
.350
SECTION C-C
F08615 78 C-3001
B
X722394
1

LTR	ZONE	DESCRIPTION	DATE	APPROVED
A	A6	(1) REDESIGNED TO EXISTING CONFIGURATION OF DETAIL COMPONENTS (ECN A1131)	[illegible]	[illegible]
B	A6 D6 C7 C6 B6	(10) X7223944-11 WAS X7223944-7, X7223944-13 WAS X7223944-9, X7223945-9/10 WAS X7223945-7/8, X7223943-9/10 WAS X7223943-7/8, X7223942-9/10 WAS X7223942-7/8 (ECN B0935)	[illegible]	[illegible]



SECTION B-B A6

10. PROTECTIVE FINISH NOTED AREAS AS FOLLOWS:
A CLEAN PER MIL-S-5002
B. APPLY ONE COAT MIL-P-23377 EPOXY-POLYAMIDE PRIMER PER MIL-F-18264.

9 ENGRG REF ONLY: INITIAL RELEASED CALC WT FOR -1 IS 1055 LB

8 -1/-2 CONTAIN FRACTURE CRITICAL DETAILS RETAIN ORIGINAL DETAIL MATL TRACEABILITY NUMBERS IN ACCORDANCE WITH X7224199

7 MARK PARTS PER X7224198 CL 2A

6 PENETRANT INSPECT PER 81755/FPS-1084 ZONE 0

5 ALL EDGES .030R OR CHAM .030 X 45°

4 ALL MACHINED SURFACES 125 √

3 INSPECT WELDS PER 81755/FPS-1097 CLASS I (UT)

2 ELECTRON BEAM WELD PER 81755/FPS-1070

1 DIMENSIONS & TOLERANCES PER USASI Y14.5

NOTES (EXCEPT AS SHOWN)

SEE SE. Figure 2.1.1-13

NEXT SECTION LTR: D

U. S. AIR FORCE

DRAG FITTING, MAIN LANDING GEAR-ASSY OF

J 07878 X7223941

NONE

X7223941

3

6. Performed analysis of design changes which became necessary during the manufacturing phase arising from tooling requirements, physical interferences, and discovery of areas where strengthening or other design improvements were needed. This effort included both the simulated fuselage and the WCTS.

7. Made substantial progress in preparing a finite element model of the overall WCTS as released for manufacture.

8. Participated in planning for the full scale test program including preliminary selection of strain gage locations.

9. Prepared the preliminary test plan for the credible option fastener evaluation test program and assisted in planning the material and fatigue tests.

10. Provided structural manufacturing liaison as discrepant manufactured parts were dispositioned.

11. Transferred information to AFFDL through formal status reports, by transmittal of computer output data and other material as it became available, and during informal contacts.

12. Continued or initiated miscellaneous structural studies.

Except for a few items, the accomplishments represented a continuation of tasks begun during Phase II. Since a description of the Phase II tasks is to be found in AFFDL-TR-74-17, this report will deal primarily with additions or changes that have occurred since the preparation of TR-74-17. As noted therein, it is not considered feasible to include the large amount of analysis, but all pertinent preliminary analysis is in the contractor's files.

2.1.2.2 Design Loads

There have been no significant design load changes incorporated into the structural analysis since those described in TR-74-17 except for those related to pivot friction effects resulting from moving the wing to various sweep positions. Incremental sweep actuator loads and antirotation device loads were obtained from AFFDL and RI during January and February 1974. A summary of the values used along with wing sweep actuator loads derived from wing pivot flight loads is shown in Table 2.1.2-I. Since

Table 2.1.2-I

ULTIMATE WING SWEEP ACTUATOR
LOADS AND PIVOT PIN ANTI-ROTATION LOADS

CONVAIR COND. NO.	HARSAP COND. NO.	SWEEP ANGLE	WING MOMENTS, 10^6 IN-LB. M_X	M_Y	M_Z	$M_{Z_{PIN}}$ (WING) 10^6 IN-LB	M_Z' (FRICTION) 10^6 IN-LB	PACT WING LB.	PACT FRICTION LB.	PACT MAX. LB.	M_Z' ANTIROT. 10^6 IN-LB
USED TO OBTAIN AS1000	660331L	67.5°	44.07	-74.16	-12.678	-10.564	±4.67	-364,276	±161,034	-525,310	±3.113
	660331R	67.5°	37.46	-57.39	- 6.528	- 4 915	±4.041	-169,483	±139,345	-308,828	±2.694
AS2000	110021	15°	102.218	-26.786	- 4.245	- 4.028	±7.968	- 81,178	±160,582	-241,760	±5.312**
AS3000	161[illegible]2	67.5°	39.696	-70.567	- 5.056	- 3.034	±6 565	-104,620	±226,379	-331,000	±4.377
AS4000	110301	15°	-37.41	6.524	24.45	24.227	±4.206	488,256	± 84,765	573,021	+2.804
AS5000	112120	15°	93.347	-12.888	-22.20	-22.367	±7.286	-450,770	±146,837	-597,608	±4.857
	122221	25°	90.982	-29,539	- 2.1	- 1.725	NA				NA
AS11000	160316	67.5°	4.562	- 1.363	24.0	24.018	±1.855	828,207	± 63,966	892,172	±1.237
AS10000	160337	67.5°	51.371	-88.334	-12.55	-10.026	±7.654	-345,724	±263,931	-609,655	±5.103

NOTES: $(M_{Z_{PIN}})_{WING} = .999462\ M_Z - .006338\ M_X - .032186\ M_Y$

ACTUATOR MOMENT ARM = 29.0 IN. FOR = 67.5°

ACTUATOR MOMENT ARM = 49.6195 IN. FOR = 15°

$M_Z' = \quad = M_Z'{}_{FRICTION}/1.5$

the design was considered frozen at the time this data was received, no further revisions were incorporated. RI criteria specifies ultimate friction effects for combination with flight loads on the wing sweep actuator support structures. On the other hand, limit friction effects are specified for antirotation device loads except for 1g conditions where ultimate loads are used throughout. The use of limit load on the antirotation device accounts for the fact that some rotational restraint is provided by a friction moment at the pin system - WCTS lug interface.

2.1.2.3 Weight Reduction Support

An important part of the structures task was to review the stress analysis data on hand to determine where excess weight existed because of conservativisms or because of material left in place for ease of manufacture. Such areas were found on all major components of the WCTS and as redesigns were made, additional analysis was performed to assure that sufficient strength remained after weight reduction changes were made. Both manual and computer aided analyses were carried out during the weight reduction effort. These analyses are discussed in subsequent sections where pertinent. Copies of the preliminary analysis were furnished to AFFDL.

2.1.2.4 Updating of Overall TN1 WCTS Math Model

Because of numerous changes made during the completion of the design, including the effects of the weight reduction effort, the NBB-4 series of models was no longer representative of the actual structure. Thus, work was begun on a new model which would incorporate the geometry of the current WCTS as it is being manufactured. The number of elements and nodes are expected to increase somewhat, but the model will have essentially the same grid fineness as the NBB-4 series with improvements being made where feasible. All of the major components were gridded. Element areas and thicknesses are in the process of being determined. The panel point loads are being updated to reflect the new node locations and the effects of wing sweeping pivot friction. The basic procedure for determining a set of balanced panel point loads is as described in AFFDL-TR-74-17, Section 2 with modifications being made to allow inclusion of the pivot friction effects on sweep actuator, pivot, and antirotation device support point loads.

2.1.2.5 NASTRAN Buckling Models

Numerous NASTRAN buckling models representing various major structural components were run. Additional experience with the procedure indicated that minimum eigenvalues could be missed unless care was taken in specifying the range and number of desired roots. Rerunning of upper lug models indicated that such minimums had indeed been missed. For this reason and because of changes made during the weight reduction program, final models were run. The results are shown in Table 2.1.2-II.

2.1.2.6 Fine Grid Models

Fine grid models were used where appropriate to determine more accurate internal loads and stress distributions.

Lower Lug Model

The first linear strain TLO model was run and the results were used to obtain stresses and to obtain loads between the layers of elements. The latter values were used to estimate bolt loads for the reinforcing plate attach bolts. This model was subsequently updated to represent the reduced weight design. Two conditions were run, AS2000 and AS10000. Initial review of the results indicated that the design is satisfactory. A sketch of the grid arrangement is shown in Figure 2.1.2-1.

MLG Side Brace Fitting Model

As a result of the weight reduction program a more accurate determination of internal loads for the titanium version of MLG side brace fitting became necessary. Consequently, the fitting was modeled with constant strain membrane elements. The intention was to use Convair frontal procedure UGO; however, because of problems encountered in reducing the front to the limiting value required by the program, the run was made with TN1. Because of the complexity of the fitting, emphasis was placed on developing a model with stiffnesses that would give reasonably correct internal loads and redundant reactions. These values were then used to manually compute stresses which were more meaningful than those output by the program.

Miscellaneous Fine Grid Models

The following areas were also modeled:

Table 2.1.2-II

NASTRAN BUCKLING MODEL RESULTS

COMPONENT	CONDITION	MINIMUM EIGENVALUE	MODE OF BUCKLING
Upper Lug-Plate	AS2000	1.26	General plate and stiffener instability between closure rib and X_{F84} (See Figure
	AS10000	1.48	Normal deflection of leading edge of plate. (See Figure
Closure Rib	AS10000	1.90	General instability of web and stiffeners in the aft portion of the rib.
X_F84 Rib	AS5000	1.82	Lateral deflection of chordwise member along lower edge of access hole.
	AS10000	1.81	Plate buckling below access hole.

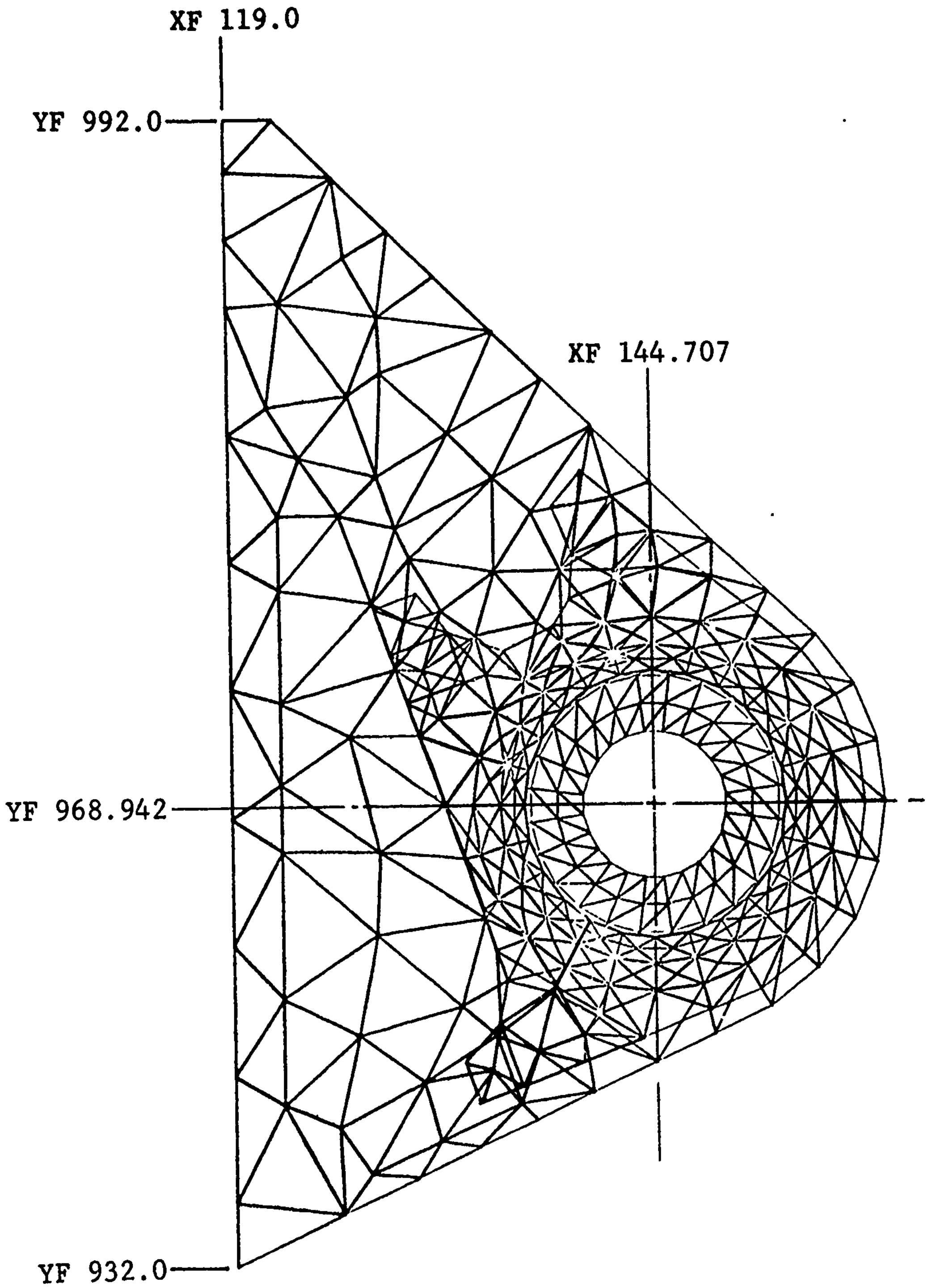


Figure 2.1.2-1 TL Ø SIMULATION NBB
REVISED LOWER LUG

a. Upper forward outboard longeron to WCTS attach region.

b. Lower forward outboard longeron to WCTS region.

c. Y_F932 and Y_F992 bulkhead upper flanges at X_F84 and X_F39.

The bulkhead models were run to ascertain the magnitude of the flange bending stresses developed as the loads in the outstanding flanges changed direction and to obtain loads for analyzing support structure added to alleviate the flange bending stresses.

Convair procedure TE7, which includes constant stress plate and membrane elements, was used for the first two models. NASTRAN was used for the latter models so that both buckling and stress analysis could be accomplished.

2.1.2.7 Drawing Analysis

Preliminary stress analysis of all WCTS, simulated fuselage, and miscellaneous full scale test parts was completed. Local areas which were affected by wing pivot friction loads acting in combination with other flight loads were reanalyzed and required changes determined. Design changes were analyzed on a progressive basis as the manufacturing phase began and such changes became necessary.

2.1.2.8 Full Scale Test Support

Based on a review of the probable critical regions of the WCTS and in coordination with the fracture and fatigue group, preliminary strain gage locations were selected. These gages required 450 channels. The purposes of the gages are to determine stress distributions and to monitor the structure during the test to detect actual or impending failures.

2.1.2.9 Current Weight Status

The WCTS current weight status is shown in Table 2.1.2-III. This weight is based on nominal dimensions (mid-point of tolerance range) and shows a 9.08% reduction from the baseline weight of 13764 pounds. Analysis and additional checking of the detail weight calculations is continuing, especially with regard to the miscellaneous category.

Table 2.1.2-III

GENERAL DYNAMICS — CONVAIR AEROSPACE DIVISION — FORT WORTH OPERATION
6600 PROCEDURE R1K — PROBLEM 005465-08 — 04/29/74 PAGE 0113

NO-BOX BOX (WBP)-ADVANCE METALLIC WING CARRY THRU STRUCTURE
DESIGN GROUP 64 TOTAL

WEIGHT SUMMARY

	119 OUTBOARD	84 - 119 INTERMDTE	0 - 84 CENTER	TOTAL STRUCTURE
STRUCTURAL BOX	2432.6	3094.6	3649.1	9176.4
LOWER PLATE	1008.3	1069.5	891.4	2969.2
COVER	0.0	1069.5	891.4	1960.9
LUGS	1008.3	0.0	0.0	1008.3
UPPER PLATE	744.6	968.0	401.4	2114.1
COVER	0.0	968.0	401.4	1369.4
LUGS	744.6	0.0	0.0	744.6
BULKHEADS	20.6	692.1	1623.0	2335.6
932 BULKHEAD	0.0	404.2	758.2	1162.4
947 BULKHEAD	0.0	0.0	161.6	161.6
962 BULKHEAD	0.0	0.0	0.0	0.0
977 BULKHEAD	0.0	0.0	0.0	0.0
992 BULKHEAD	20.6	287.9	703.1	1011.6
RIBS	492.5	233.5	505.6	1231.6
0 BUTTLINE	0.0	0.0	187.5	187.5
39 BUTTLINE	0.0	0.0	318.1	318.1
84 BUTTLINE	0.0	233.5	0.0	233.5
120 BUTTLINE	492.5	0.0	0.0	492.5
MISCELLANEOUS	166.7	131.6	227.7	525.9
MISCELLANEOUS	166.7	131.6	227.7	525.9
FITTINGS	1543.0	511.1	885.7	2939.8
XF72 TRUNNION	0.0	0.0	169.1	169.1
XF95 TRUNNION	0.0	113.7	0.0	113.7
992 SIDE BRACE	0.0	0.0	182.8	182.8
MLG DRAG BRACE	0.0	0.0	170.0	170.0
WING SWEEP ACT	0.0	362.0	0.0	362.0
PIN/SHEAR/NAC	1433.5	0.0	0.0	1433.5
XF0 LONGERON WF	0.0	0.0	38.8	38.8
LONGERON LOWER	0.0	35.4	0.0	35.4
LONGERON UPPER	40.0	0.0	0.0	40.0
LONGERON 25 DEG	0.0	0.0	140.0	140.0
LONGERON DORSAL	0.0	0.0	185.0	185.0
LUG PIN	69.6	0.0	0.0	69.6
SUBTOTAL	3975.6	3605.7	4534.8	12116.1
MISCELLANEOUS	22.3	143.3	233.0	398.6
SUBTOTAL	22.3	143.3	233.0	398.6
UPPER FAIRING	11.2	101.3	0.0	112.5
LOWER FAIRING	0.0	22.5	148.5	171.0
EXTERIOR FINISH	1.2	.8	5.4	7.4
FILLETS	0.0	0.0	15.0	15.0
PROVISIONS-FUEL	9.9	7.9	37.6	55.4
PROVISIONS-HYD	0.0	0.0	2.0	2.0
PROVISIONS-AUX G	0.0	10.7	4.5	15.2
PROVISIONS-ELEC	0.0	0.0	20.0	20.0
	0.0	0.0	0.0	0.0
TOTAL	3997.9	3749.0	4767.8	12514.7

A number of detail parts have been weighed. The earlier parts weighed were parts of welded assemblies which will be subsequently machined. These weights are not being reported in actual weights.

One hundred detail parts have been weighed for the box assembly. The cumulative weights for these parts is 2958.8 pounds calculated and 2986.8 pounds actual. This is less than one percent weight growth calculated to actual. Two of these parts are of particular interest in comparing actual weight-to-calculated-weight since they were machined on numerically controlled machines.

The lower plate, X7224175-7, weighed 2446.5 pounds when it was removed from machine. The reported weight is 2436.7 pounds for this part. This indicates a 9.8 pound overweight condition; however, hand finish work and deburring are in progress. The actual weight will be revised when this work is complete.

The lower plate bonded assembly skin, X7224173-7, which was the first numerical controlled machined part, was weighed at 124.1 pounds. This is 4.7 pounds under the reported weight of 128.8 pounds, about 3%.

2.1.2.10 Credible Option Weight Impact

The Air Force statement of work for the credible option program requires that the weight impacts of the interface changes and the gross weight increase be evaluated separately. The following data shows those impacts for the NBB configuration:

The interface changes/load condition update affected the weight of the WCTS as follows:

(1) Wing intrusion elimination altered the interface loads between the WCTS and the fuselage. Outboard longeron loads were increased.

(2) A new aft-sweep condition (160337) produced about 14% greater torsion loads at the wing pivot.

(3) Revised fairing support requirements dictated the use of a lug rib (X7224005) which was not previously required.

A finite element analysis of the WCTS was made for the interface loads resulting from the above changes and a required weight was obtained from this analysis. The same model was run for the interface loads for the critical aft-sweep condition prior to the credible option changes and a required weight was obtained. The weight required by the new loads was 336 pounds greater than that required for the previous loads. This data is shown on pages 2-129 and 2-130 of AFFDL-TR-74-17.

The weight of the lug rib required to support the fairing loads is 69.6 pounds. This weight is shown in the current weight status, Table 2.1.2-III.

The impact of the 10% gross weight increase is determined from the current weight status by assigning an impact factor to each major structural component as shown below. Structures designed by fatigue requirements are not affected by the gross weight increase in accordance with the fatigue analysis procedures for the credible option task.

The lower plate and lugs are designed primarily by fatigue requirements. An impact factor of 1% is adopted to account for some local stability requirements and the effect of net section losses in some areas where larger fasteners are needed to meet static load requirements.

Bulkhead and rib structures are designed by fatigue requirements in the lower portions and by stability and static strength requirements in the upper portions. An average impact factor of 5% (midway between zero for fatigue areas and the full 10% load increase) is used for this structure.

The upper cover and lug structure is designed primarily by stability considerations. A factor of 7% is used in recognition of the fact that some increase in the allowable stress will result from the thickness increases so that a full 10% penalty is not required.

The MLG fittings, wing sweep actuator fittings and longeron fittings are designed by a combination of static and fatigue requirements. In general, it was not necessary to increase the thickness of the flanges which attach to the WCTS. An impact factor of 4% is used for these fittings.

The structural box miscellaneous weight category consists primarily of fasteners. Since many of these fastener sizes are based on uniformity of fastener sizes used in a particular joint, an impact factor of 3% is used to account for local size increases.

ITEM	CURRENT WEIGHT (LB)	IMPACT FACTOR	WEIGHT IMPACT (LB)
LOWER PLATE	2969.2	.01	29.7
UPPER PLATE	2114.1	.07	148.0
BULKHEAD	2335.6	.05	116.8
RIBS	1231.6	.05	61.6
FITTINGS	1073.0	.04	42.9
MISCELLANEOUS	525.9	.03	15.8
TOTAL IMPACT (GROSS WEIGHT INCREASE)			414.8

In summary, the weight impact on the NBB WCTS of the Credible Option update is:

Interface Changes	405.6 lb.
Gross Weight Change	414.8 lb.
Total Impact	820.4 lb.

Similar data is shown for the FSIL configuration on page 2-260 of AFFDL-TR-74-17.

2.1.3 Fatigue and Fracture Analysis

The fatigue and fracture analysis tasks during this reporting period were directed toward completion of the detail design phase, drawing sign-out, and implementation of the fracture control plan. In addition, significant contributions were made to the test plan for the full scale test program and to the test plans for the credible option test programs. Preliminary versions of each of the test plans have been published under separate covers: FZS-219, (Full-Scale Test Program), FZM-‘999 Addendum I (Material Tests) and FZM-6054 Addendum I (Fastener Tests).

A final version of the fracture critical parts list was distributed. This list, shown in Figure 2.1.3-1, identifies parts at the detail level.

Fracture control requirements applicable at the assembly level (e.g. traceability and planning approval) are specified by the following drawing callout:

-XX contains Fracture Critical details. Retain original detail material traceability numbers in accordance with X7224199.

X7224012-7	Blank Plate, Pivot Lug-Upper, Wing Carrythrough
4031-7/-8	Web, Closure Rib - Outboard
4032-7/-8/-9/-10	Support, Actuator Fitting-Outboard Closure Rib
4061-7	Web, Y_F992 Bulkhead-Inboard, Assy. of
4073-7/-8	Cap, Bulkhead-Y_F992, Lower Outboard
4074-7	Cap, Bulkhead-Y_F992 Upper Outboard
4075-7/-8	Web, Bulkhead-Y_F992, Outboard
4082-7/-8	Bulkhead Panel-Center, Y_F932, Assy. of
4083-7/-8	Bulkhead Panel-Outb'd, Y_F932, Assy. of
4085-7/-8	Gusset, Y_F932 Bulkhead
4093-7/-8	Cap, Lower Outbd-Bulkhead Y_F932
4095-7/-8	Web, Outb'd-Bulkhead Y_F932
4172-7/-8	Panel, Lower-X_F39 to X_F84, Assy. of
4173-7	Web, Lower Plate-Center, Wing Carry-through, Assy. of
4175-7	Pivot Lug-Lower Wing Carrythrough
4175-7/-8/-9/-10	Reinforcement-Pivot Lug, Lower
4181-7/-8	Beam, Y_F947-MLG Drag Brace, Wing Carrythrough
X7223901-9/-10	Support Fitting-Wing Sweep Actuator
3921-7/-8	Fitting, Main Landing Gear-Side Brace Support, Outboard
3923-7/-8	Fitting, Main Landing Gear-Side Brace Support, Inboard
3924-7/-8	Fitting, Main Landing Gear-Side Brace Support, Upper
3931-7/-8	Trunnion-Main Landing Gear, X_F95.5
3942-9/-10	Drag Fitting, Main Landing Gear-Inboard Beam
3943-9/-10	Drag Fitting, Main Landing Gear-Outboard Beam
3944-11/-13	Beam Extension, Drag Fitting-MLG
3945-9/-10	Drag Fitting, Main Landing Gear-Splice

Figure 2.1.3-1
FRACTURE CRITICAL PARTS LIST
(Revised 4-15-74)

2.1.4 Materials Engineering

2.1.4.1 Materials Procurement

All materials were procurred for the fabrication of the AMAVS Carrythrough Structure except the 3.0" thick 10 Nickel steel for the Upper Surface Lugs. The three pieces on order are scheduled for delivery in late July. The ingot for these upper lugs was delivered to U.S. Steel's Homestead plant on 5 May 1974. It has presently been forged into rolling slab size and is ready for rolling into plate. The plate will be cut into three pieces prior to solution treatment, and after solution treatment by U.S. Steel it will be bent to the upper lug angle. After the forming operation, the three plates will be aged to condition STA (Solution Treated and Aged). The forming operation eliminates a major machining operation that would have necessitated the purchase of much thicker plate.

The condition of the remainder of the 10 Nickel steel plates as received is shown in Figure 2.1.4-1. Two forged plates, 7.5" and 6.0" thick as forged, have also been received but are not included in the photograph.

2.1.4.2 Materials Test Data Report

All the test data generated in this program is being reported in a separate report. Interim reports, FZM-6148 dated April 1973 and FZM-6148A dated January 1974, have been published and submitted to the AMS/ADPO. FZM-6148A actually contains all the test data required by the Phase Ib and Phase II program except for a portion of the data generated on brazed specimens. Additional testing is planned as part of the credible option task and the test results will become part of the final test report. A materials test plan addendum has been prepared and submitted for the credible option task.

2.1.4.3 Design Allowables

The design allowables for the new materials utilized in this program were published in AFFDL-TR-74-17. This included allowables for beta annealed 6Al-4V titanium, 7050 aluminum, 10 Nickel steel and weldments in both the titanium and steel alloys. Additional data on beta annealed 6Al-4V has allowed the expansion of the design allowables to thicknesses up to 7.500 inches thick

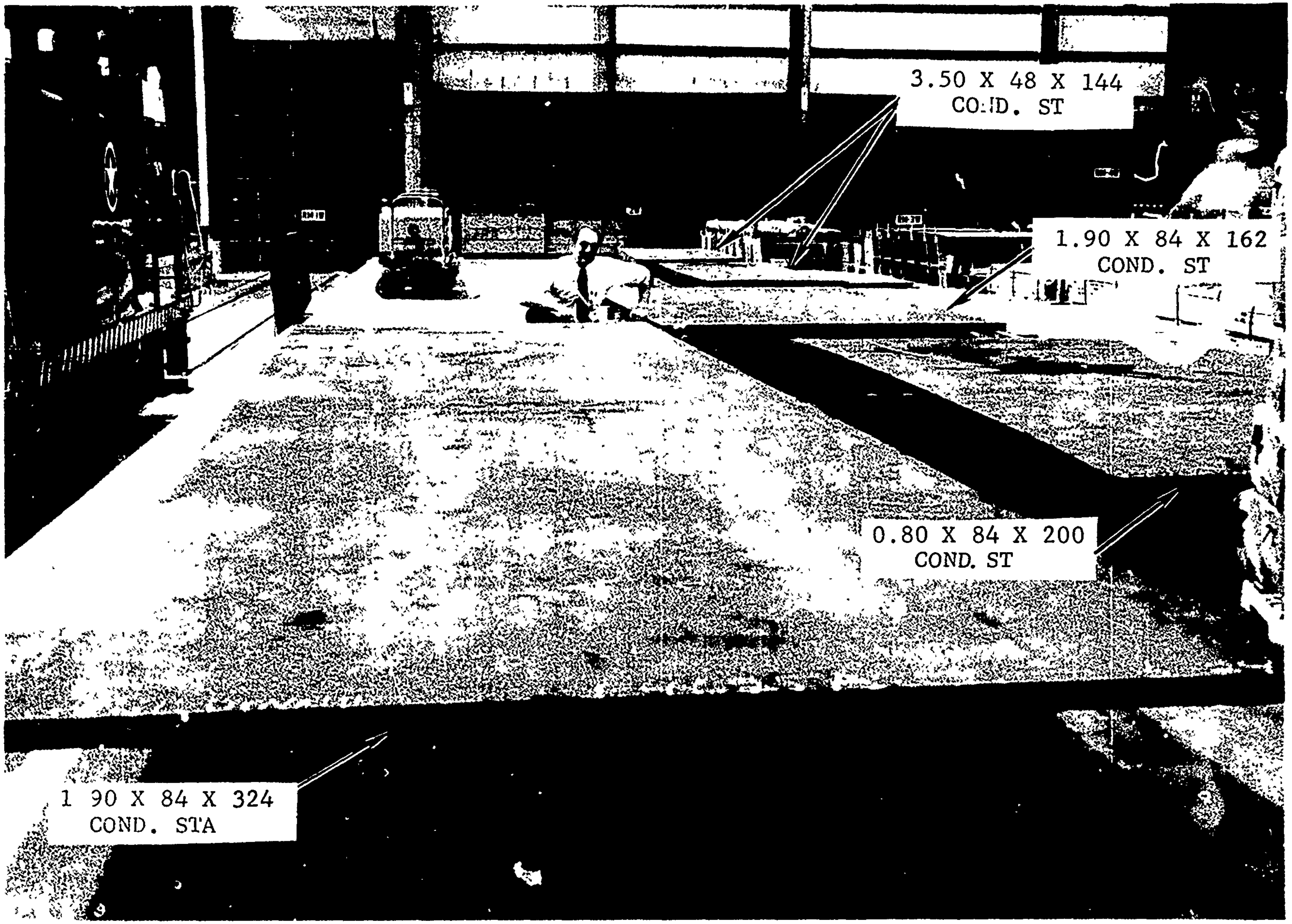


Figure 2.1.4-1 10 NICKEL STEEL PLATES AS RECEIVED

and these revised allowables are included in Tables 2.1.4-I. Design allowables for the 7050 aluminum alloy as used in the AMAVS program have also been revised and are shown in Table 2.1.4-II. This revision reflects the latest data generated by ALCOA and does not impact present AMAVS designs.

2.1.4.4 Brazing

Brazing activities have been terminated since the decision to fabricate and test the "No-Box" Box configuration was made. A brazing process was developed which produced large (4 ft. x 10 ft.) panels with braze joints exhibiting excellent shear strength and resistance to stress corrosion delamination. The braze thermal cycle is shown in Figure 2.1.4-2 with the thermal history trace for the last 603FTB035 panel shown. The panel performed successfully during its test and specimens removed from the panel had good shear strength and stress corrosion delamination resistance. The results of sustained load stress corrosion tests to determine the effects of different brazing cycles are shown in Figure 2.1.4-3. Details of the brazing process developed are included in AFFDL-TR-74-17.

2.1.4.5 Adhesive Bonding

Adhesive, adhesive corrosion inhibiting primer and core splice materials per FMS-1116 have been received. A problem was encountered with the adhesive on receiving inspection tests. The inherent high flow of the material and entrapped air in the adhesive film combined to create excessive flow of the adhesive from the 1/2-inch overlap specimen. Room temperature lapshear results were just above specification and results at 180°F were below. Examination of the specimen showed a highly porous bond line. The peel specimens with their larger 1" wide bond area did not show the effect. No effect was noted on honeycomb sandwich bonding ability. The data from these tests are included in FZM-6148A.

It was anticipated that oven aging of adhesive film after application of the adhesive to the 1/2-inch overlap specimen would correct the situation by reducing the flow of the resin and driving off most of the absorbed air in the film. A temperature of 200°F was selected and unassembled lapshear details with the adhesive applied were aged for times ranging from 20 minutes to 60 minutes. All of the aging times produced acceptable results. The 20 minute age time was tested in floating roller peel and found acceptable. This time has been selected for a process change to

Table 2.1.4-I

DESIGN ALLOWABLES

For Ti 6Al-4V

Beta Annealed Condition

(Ref. FMS-1109A)

FORM - PLATE AND FORGED BILLET

Thickness (Inches)	.188-.500	.501-1.000	1.001-2.000	2.001-4.000	4.001-5.750	5.751-7.500
Property:						
F_{tu} (KSI)	130	127	125	122	120	115
F_{ty} (KSI)	115	115	112	110	105	100
F_{cy} (KSI)	121	121	118	116	110	105
F_{su} (KSI)	87	85	83	81	80	77
F_{bru} (KSI)						
e/D = 1.5	208	203	200	195	192	184
e/D = 2.0	267	260	256	250	246	236
F_{bry} (KSI)						
e/D = 1.5	140	140	136	134	128	122
e/D = 2.0	170	170	166	163	155	148
% Elong (L or LT)	10	10	8	8	8	8
E (10^6 psi)	16.0					
E_e (10^6 psi)	16.4					
K_{IC} (KSI $\sqrt{\text{inch}}$)	90 (TYP) 80 (MIN)					
K_{Iscc} (KSI $\sqrt{\text{inch}}$) typ	60+					
ρ (lbs/in^3)	.160					

2-19-74

Table 2.1.4-II

DESIGN ALLOWABLES
7050 ALUMINUM ALLOY PLATE

TEMPER		7050-T7651	7050-T73651				
THICKNESS		.250-1.00	1.501 2.00	2.01-3.00	3.01-4.00	4.01 5.00	5.01-6:00
F_{tu}(KSI)	L	77	71	71	69	67	66
	LT	78	72	72	70	68	67
	ST			68	66	64	63
F_{ty}(KSI)	L	69	63	63	60	58	56
	LT	67	63	63	60	58	56
	ST	-	-	59	56	54	53
F_{cy}(KSI)	L	69	61	60	57	55	52
	LT	72	65	66	63	61	59
	ST	-	-	64	61	58	57
F_{su}(KSI)		44	43	43	43	42	42
F_{bru}(KSI)	e/D = 1.5	116	110	110	107	104	103
	e/D = 2.0	151	142	142	138	134	132
F_{bry}(KSI)	e/D = 1.5	97	91	92	89	87	85
	e/D = 2.0	113	104	105	102	100	99
% Elong.	L	7	9	9	9	9	8
	LT	7	6	6	6	5	5
	ST	-	-	2	2	2	2
E (10^6 psi)		10.3					
E_C (10^6 psi)		10.5					
ρ (lbs/in^3)		.102					
K_{IC} (KSI $\sqrt{in.}$) (Typ)		32 (L-T), 27 (T-L), 24 (S-L)					
K_{Iscc} (KSI $\sqrt{in.}$)		Resistant in T73651 temper 90-95% of K_{IC}					

TENSILE DATA BASED ON ALCOA GREEN LETTER GL220(4-73);THEN REVISED PER ALCOA TENTH BI-MONTHLY PROGRESS LTR: NASC CONTRACT N00019-72-C-0512. 8 May 1974.

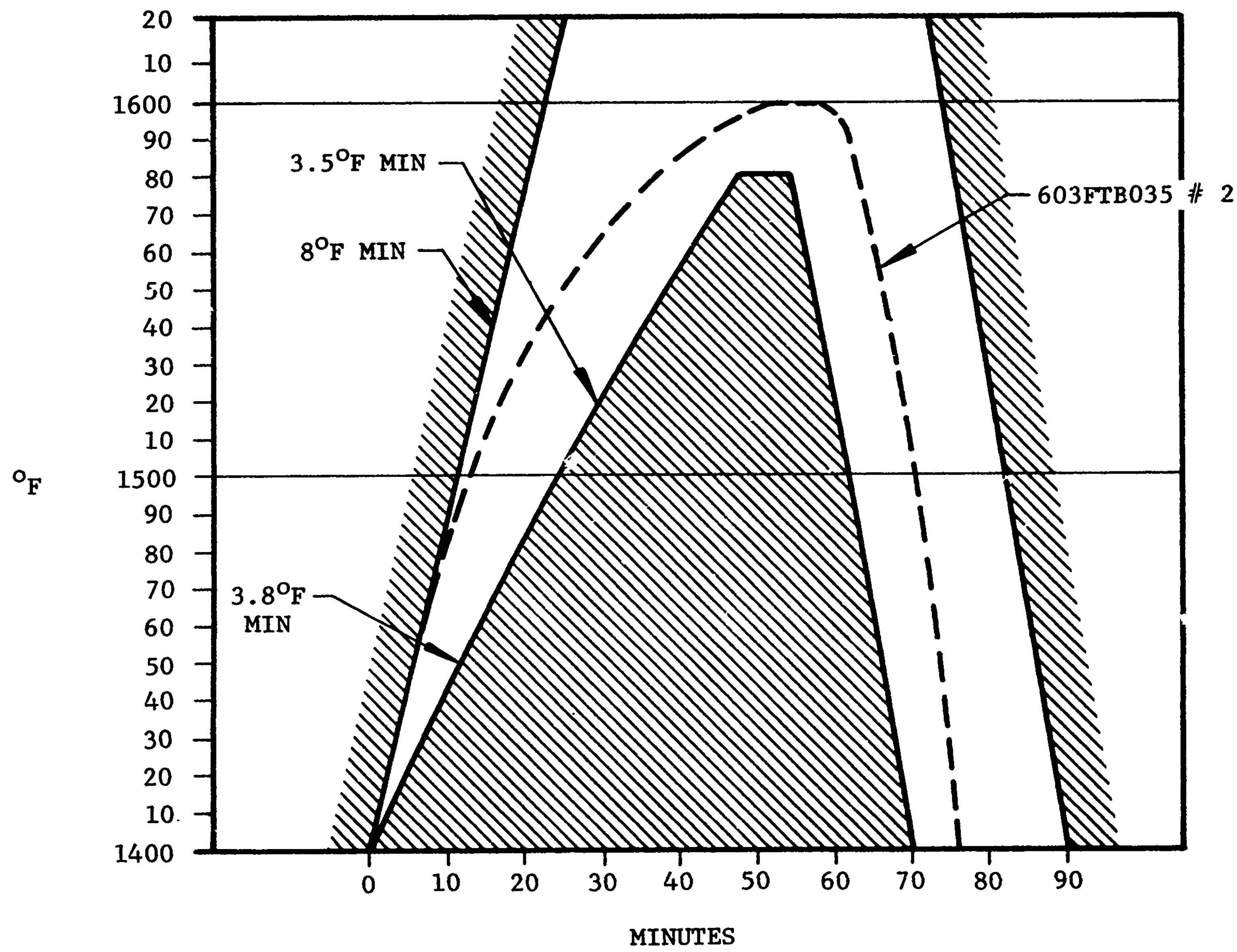
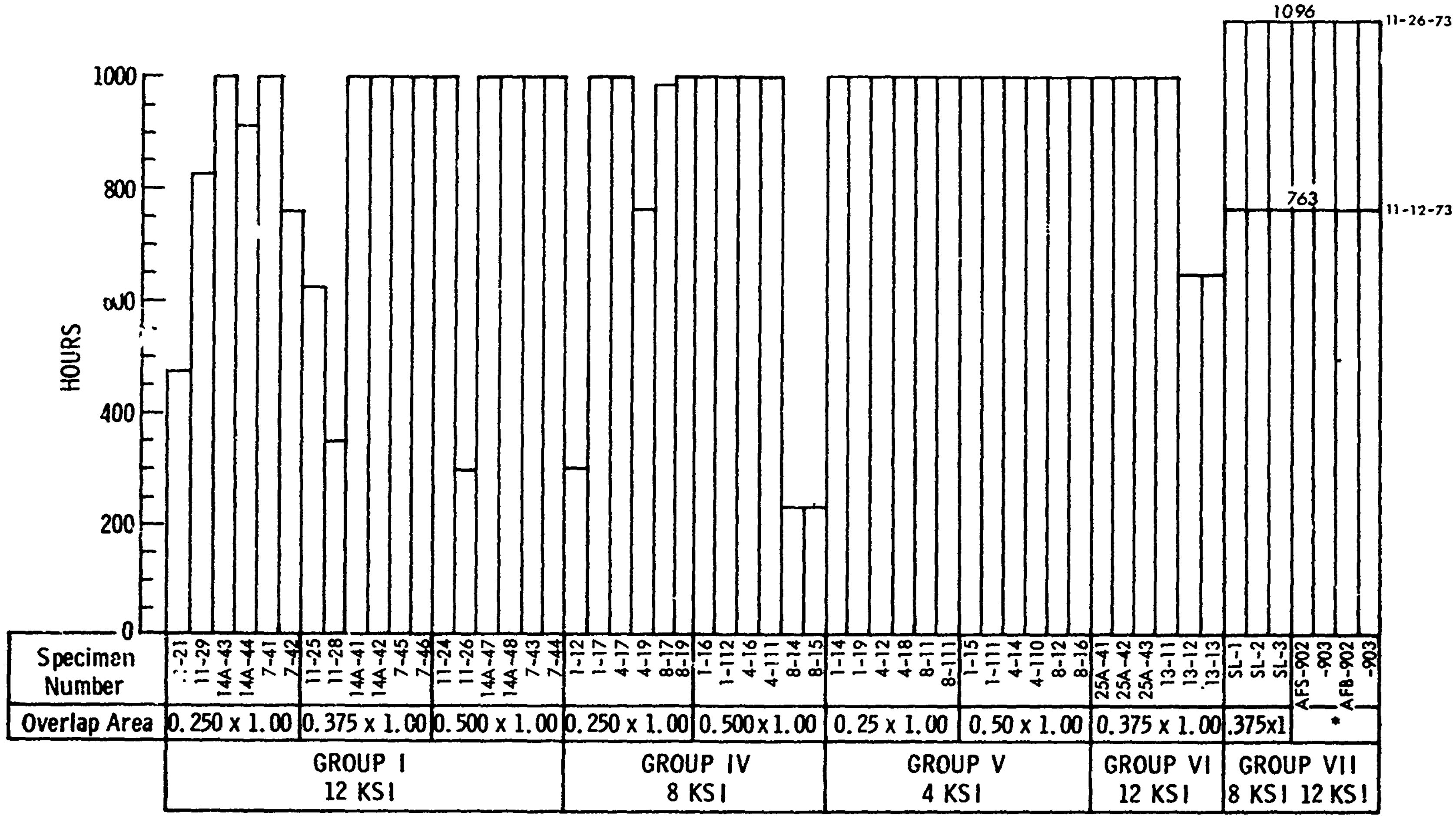


Figure 2.1.4-2 AMAVS BRAZING CYCLE TIME-TEMPERATURE BOUNDARIES



MR&D Panel Number and Test Condition					
BZ 11	Fast Heating Cycle	BZ 4	Sanded Details (63 RMS)	*Vac. Furnace	
BZ 14A	30 Min. @ BZ Temp	BZ 8	Low Pressure	BZ - Small Spcm.	
BZ 7	Good BZ	BZ 25A	Good BZ	from AFML	
BZ 1	No Buttons, 63 RMS	BZ 13	Double Cycle Perform		

Figure 2.1.4-3 SUSTAINED LOAD STRESS CORROSION TESTS BRAZED SINGLE LAP SHEAR SPECIMENS

age zee edge members (adhesive applied) of sandwich panels which contain 1/2" overlap bond areas. This will be accomplished prior to panel assembly for bonding. No change will be made in processing of the sandwich bond area.

2.1.4.6 Welding Developments

A discussion of the welding activities during this reporting period is contained below.

Electron Beam Welding of Titanium - Murdock Machine and Engineering Company of Texas, a Division of Lockheed Corporation, has been selected to Electron Beam (EB) weld the X7223941 MLG Drag Brace Fitting. Their contract requires them to weld using their specification LCP74-2022B which requires certification tests be conducted for each weld joint thickness to be welded. These tests include tensile and bend testing of welded joints along with metallographic examination which have been successfully completed.

In order to further evaluate Murdock weldments, two test plates were welded by Murdock for testing at General Dynamics, Convair Aerospace Division, Fort Worth Operation. Tests include tensile, fatigue and stress corrosion cracking resistance ($K_{I_{SCC}}$) in sump tank water (STW) along with metallographic examination. Figure 2.1.4-4 shows these two welded plates which are identified as MR-1 and MR-2. This figure shows the weld side of MR-1 and the back side of MR-2 with the weld back-up bars and weld run-in tabs still in place. The weld schedule used for these plates is shown in Table 2.1.4-III which is the same as that used for the joint thickness of 1.3" certified by Murdock for X7223941.

Figures 2.1.4-5 and 2.1.4-6 are layouts of MR-1 and MR-2, respectively, showing where all test specimens are located. In addition, the layouts also show the results of ultrasonic inspection. Note that a part of the test specimen is specifically located in the area of ultrasonic indications to determine effect, if any, on fatigue properties.

Table 2.1.4-IV presents the test results of the tensile tests from the two test plates and Figure 2.1.4-7 is a photograph of the failed test specimen. All failures were parent metal failures and met the same properties as the parent plates. Figures 2.1.4-8 and 2.1.4-9 are macrographs of the weld joint of MR-1 and MR-2, respectively. The remainder of the tests planned for these plates are in work and will be completed soon.

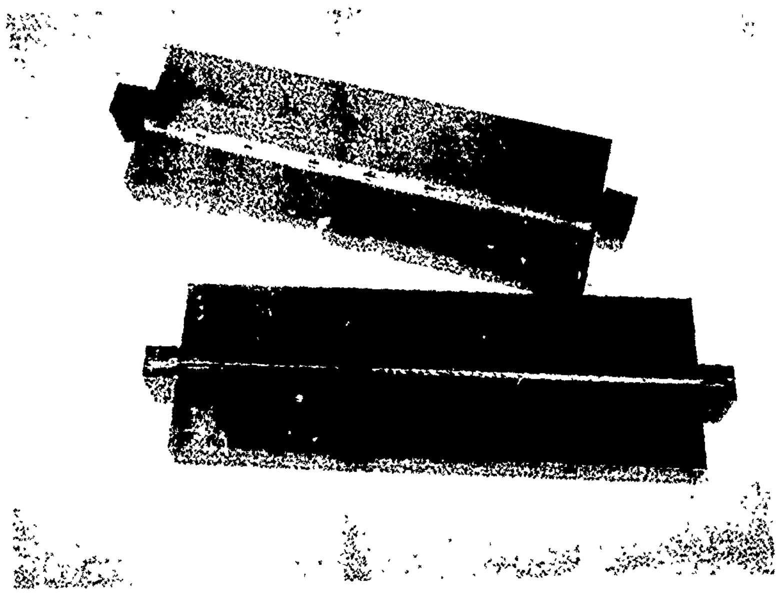


Figure 2.1.4-4 TEST PLATES WELDED BY MURDOCK

MACHINE AND ENGINEERING COMPANY OF TEXAS
[illegible] P.O. BOX [illegible]
IRVING, TEXAS [illegible]
TELEPHONE (214) 255 0511
TWX 910-860-5101

WELD PROCEDURE NO: GD-1
REVISION: ORIGINAL
DATE: 4-22-74

Table 2.1.4-III

ELECTRON BEAM WELD PROCEDURE DATA SHEET

WELD EQUIPMENT S/N: 9568

PART NO: X7223941-1/2 TOOL NO: T17378 WLEX
PART NAME: M.L.G. DRAG FITTING TYPE MAT'L 6AL 4V TITANIUM

CLEANING SPEC: LCP76-1019
FILAMENT ADJUST: 45 MINIMUM
GUASS METER READING: +- 1.0
TYPE FILAMENT: 500 Ma
GUN TO WORK DISTANCE: 5.50 INCHES
WELD POSITION: HORIZONTAL
ANODE SIZE: BM 5740

TYPE JOINT: BUTT
BACK UP BLOCK MAT'L 6AL 4V TI
PUMP DOWN TIME: 20 MINUTES
ANODE-CATHODE SPACER: .425
GUN ANGLE 90° TO WORK SURFACE
FILAMENT-CATHODE DIST. .392
CATHODE SIZE: BK 2501

KW = 13.49

BEAM CURRENT SETTING	3 8 0	METER	3 6 0
FOCUS SETTING	5 1 0	METER	4 0 0
HIGH VOLTAGE SETTING	3 5 5	METER	3 5 0
TRAVEL SETTING	2 5 0	DIRECTION	X-AXIS
INITIAL VOLTAGE	1 5 0	SLOPE	0 5 0
FINAL VOLTAGE	0 0 0	SLOPE	0 0 0
INITIAL CURRENT	1 0 0	SLOPE	0 5 0
FINAL CURRENT	0 0 0	SLOPE	0 0 0
TACK WELD	0 0 0	MOTOR START	0 5 0
AUTOMATIC RUN	0 0 0	SLOPE	0 0 0

NOTES: WELD K.W. SHALL BE MAINTAINED WITHIN ±5%. ALL CHANGES TO THIS PROCEDURE MUST HAVE THE WELD ENGINEER AND Q.A. APPROVAL.

[illegible]

MACROSECTION

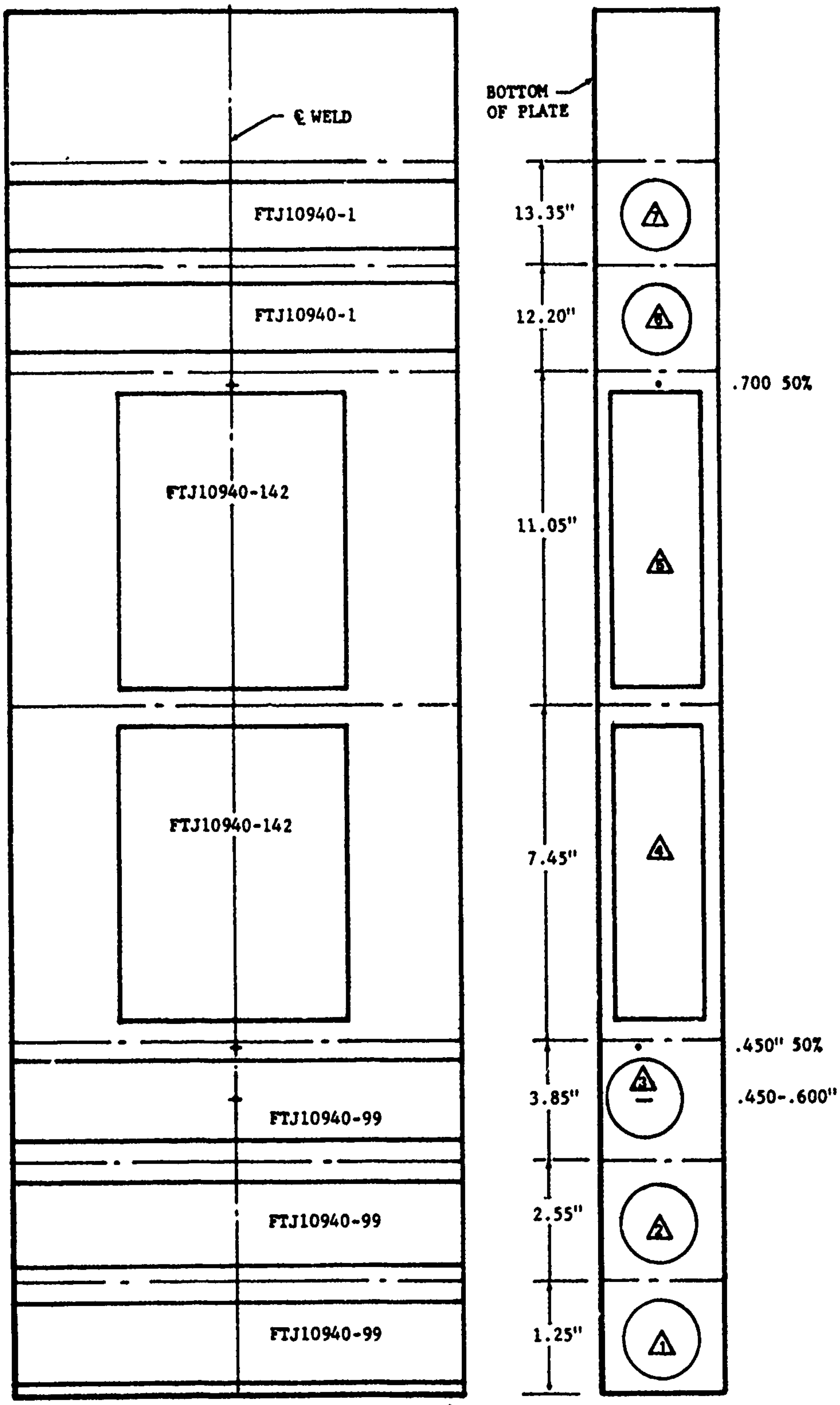
[illegible]

Witnessed [illegible]

[illegible]

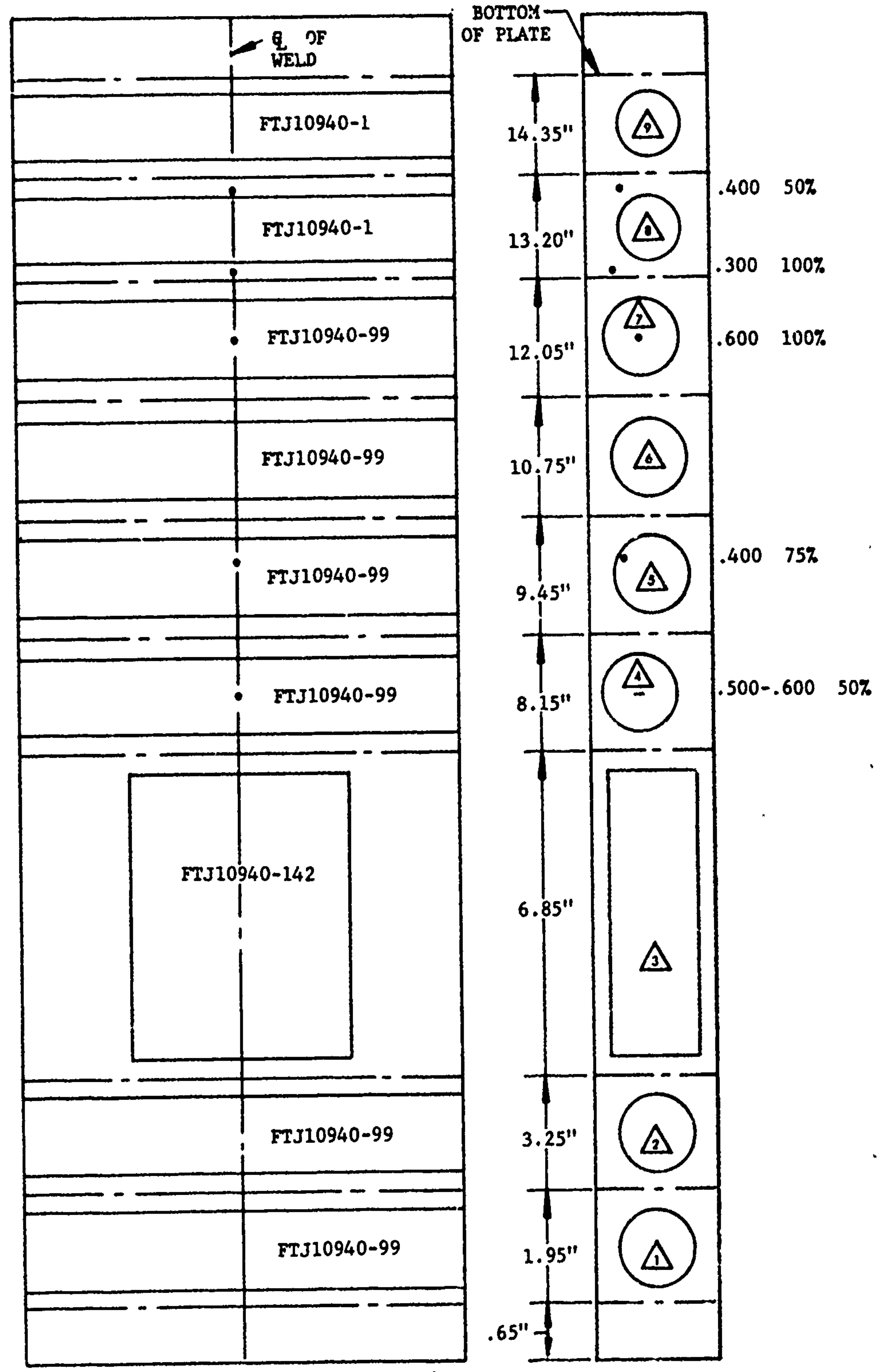
INSPECTOR [illegible]
OPERATOR: HASTINGS-[illegible]-CRISP
ENGINEER: SANDERS

(1) ______ WIDTH
(2) ______ WIDTH
(3) ______ WIDTH
(4) 1.40 MIL ______ DEPTH



NOTE: 1. Identify items as △ MR-1-_ _ _
2. All responses relative to 2/64 F.B.H.
3. X-Ray # 1K953

Figure 2.1.4-5 MATERIAL ALLOCATION FOR MR-1 PLATE ELECTRON BEAM WELD (6-4)



NOTE: 1. Identify Items △ as MR-2-
2. All Responses Rela‑ ‑e to 2/64 F.B.H.
3. X-Ray # 1K954

Figure 2.1.4-6 MATERIAL ALLOCATION FOR MR-2 PLATE ELECTRON BEAM WELD (6-4)

Table 2.1.4-IV

TENSILE PROPERTIES OF ELECTRON BEAM
WELDED TI-6AL-4V BETA ANNEALED TITANIUM 1.4" PLATE

SPECIMEN NO.	PLATE NO.	TYS KSI	TUS KSI	ELONG. % IN 2"	R.A. %	LOCATION OF FAILURE
MR 1-6	1	120.8	130.5	8.0	18.4	PM
MR 1-7	1	121.7	131.6	7.5	19.2	PM
MR 2-8	2	122.1	131.5	7.5	19.7	PM
MR 2-9	2	123.3	133.3	8.0	21.3	PM
AVG		122.0	131.7	7.8	19.7	

NOTES

A. TRANSVERSE WELD

B. 0.505" DIA. TEST SECTION

C. EB WELDED BY MURDOCK MACHINE & ENGR. CO.

D. LONGITUDINAL GRAIN DIRECTION IN PARENT METAL

E. RMI HEAT 3004600

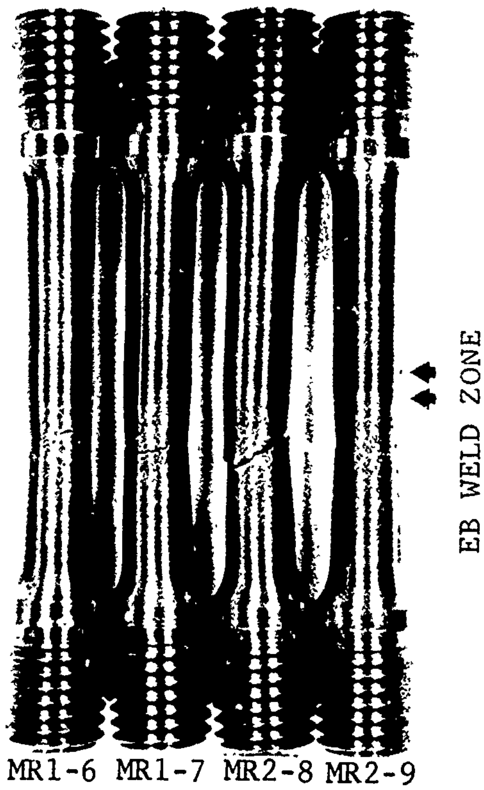


Figure 2.1.4-7 FAILED TENSILE SPECIMENS FROM MURDOCK EB WELDED PLATE

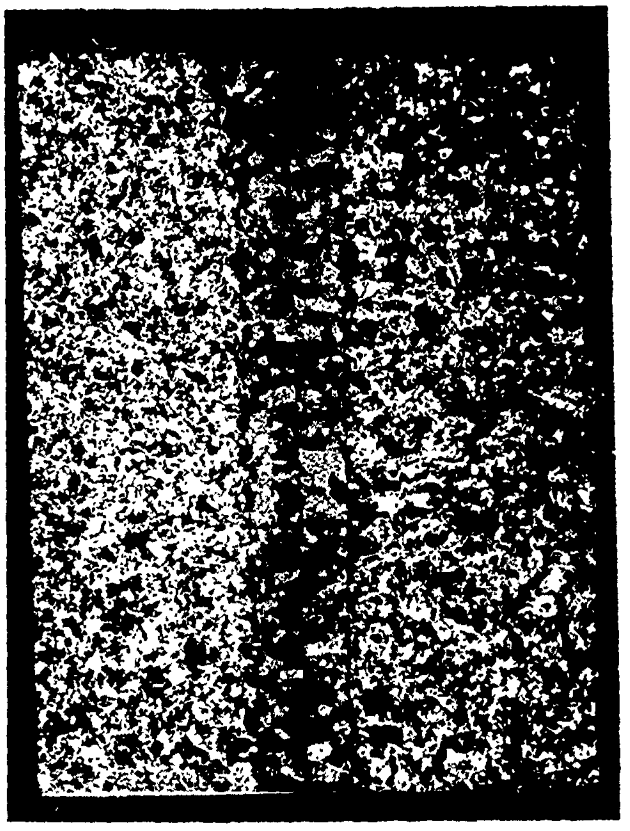


Figure 2.1.4-8 MACROGRAPH OF WELD JOINT FROM MURDOCK WELDED PLATE MR-1 (MAG 3X)

Figure 2.1.4-9 MACROGRAPH OF WELD JOINT FROM MURDOCK WELDED PLATE MR-2 (MAG 3X)

Electron Beam Welding of 10 Nickel Steel - Electron beam welding procedures for the 10 Nickel steel have now been established and seven test plates have been welded and are now in the process of being tested. They consist of five 603R100-11-3 assemblies identified as H89 through H93 inclusive and two 603R100-11-1 assemblies identified as H94 and H95. The weld schedules are shown in Tables 2.1.4-V through -XI. A layout of each test plate is shown in Figures 2.1.4-10 through -16. Each test plate layout also shows the results of ultrasonic inspection. The area where indications were found are noted and located with depth shown. All but the panel identified as H91 were inspected using a 4/64 flat bottom hole reference in accordance with FPS 1097. No indications exceeded 50% saturation except as noted. Panel H91 was inspected using a 2/64 flat bottom hole reference and percentages noted are with respect to that reference.

Two simulated tee sections identified as H99 and H100, identical in configuration to the upper bulkhead caps except for length, were welded using the weld procedure established for the X7224091 and X7224071 upper caps for the forward and aft bulkheads. A photograph of one of the welded tee sections is shown in Figure 2.1.4-17. The weld schedules for these sections are shown in Tables 2.1.4-XII and XIII. Ultrasonic inspection recorded minor indications shown in Figure 2.1.4-18 (Sheets 1 and 2, respectively). A photomacrograph of the weld joint used for certification of X7224091 is shown in Figure 2.1.4-19. Shrinkage cracks at the bottom of the weld joint had been basically eliminated by using additional power to drive the penetration into the back-up bar.

Sixteen transverse weld tensile specimens have been tested and the data is shown in Table 2.1.4-XIV. A photograph of the failed specimens from weld plates H89 and H91 is included as Figure 2.1.4-20. Only two failures occurred in the weld metal; H89-5 and H89-9. These specimen were purposely removed from known defect areas to determine the effect of the defects on the weld properties. It is interesting to note that even in the completely unacceptable GTA weld repair area ultimate and yield strengths of the parent material are obtained. Figure 2.1.4-21 is a photograph of the failure in H89-5 and shows the very small porosity in the EB weld joint. Figure 2.1.4-22 is a photograph of the failure in specimen H89-9 which was removed from an unacceptable GTA weld repair. The cracks in the weld specimen can readily be seen.

Four tensile specimens tested in the longitudinal direction have been tested and the results are shown in Table 2.1.4-XV and photographs of the failures shown in Figure 2.1.4-23.

Table 2.1.4-V

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS — Date 4-15-74

Part Number 603R100-11-3 H89 — Part Name Eng. Test (EBW) — Material Type 10 Ni

QC Serial Number 402751 — Tool Number — Mat'l. Thick 1.5

Filler Wire Type Low Alloy Hy 180 — Diameter .062

10 Ni CR-MO-CO

Ht. No. 51361

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 2	2 6 0	NA
Seconds: X 15 30 60 120	Seconds: X 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X[ ] Y[ ] — FREQUENCY, KC [ ] — RANGE [ ]

ATTENUATION, Db [ ] — METER RANGE [ ] — METER READING [ ]

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 2 0	1 2 0
Pass 2			
Pass 3			

FOCUS CURRENT METER 5.2 2 DC Amps. — GUN FILAMENT METER 0 6 8 AC Amps. — FILAMENT ADJUST POT. 0 7 6

SKETCH OF JOINT

TYPE OF JOINT: Butt

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On [ ] Off [X]

METER, AC VOLTS [ ]

VOLTAGE ADJUST. [ ]

Face Focus

GUN-TO-WORK DISTANCE, Inches 3.5

OPERATOR'S STATION CONTROL

X-AXIS On [X] Off [ ] — Y-AXIS On [ ] Off [ ]

DIRECTION Fwd. [ ] Rev. [X] — DIRECTION Fwd. [ ] Rev. [ ]

TRAVEL SPEED, IPM 1 2.0 — TRAVEL SPEED, IPM [ ]

WIRE FEED On [ ] Off [X] — INCH PER MINUTE [ ]

BEAM ALIGNMENT N A — FOCUS ADJUST. [ ]

HIGH VOLTAGE ADJUST. Noted — AVR Lock [ ] Unlock [X]

X-Ray Serial Number ______ — Beam Current Trace

Mag. Inspection ______ — Operator N. E. Wedell

Acceptance Standard ______ — MR&D Engineer J. C. Collins

Metallurgical Exam. ______ — Process Control ______

First 4" defective - ground for full thickness repaired by manual GTA. Remainder of root had incomplete penetration-Ground out 1/8" deep and repaired by GTA.

Table 2.1.4-VI

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS Date 4-16-74
Part Number 603R100-11-3 H90 Part Name Eng Test (EBW) Material Type 10 Ni (HY-180)
QC Serial Number 402755 Tool Number Mat'l. Thick 1.5
Filler Wire Type Diameter .062
Matl CSC 2500-5-1-41 thru -50

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 0	NA
Seconds: X 15 30 60 120	Seconds: X 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X [ ] Y [ ] FREQUENCY, KC [ ] RANGE [ ]
...ATION, Db [ ] METER RANGE [ ] METER READING [ ]

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 5 .0	1 2 .0
Pass 2	1 4 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER [ ] DC Amps. GUN FILAMENT METER [ ] AC Amps. FILAMENT ADJUST POT. [ ]

SKETCH OF JOINT

.5" backup with .06" x .187" groove.

TYPE OF JOINT Butt

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On [ ] Off [X]
METER, AC VOLTS [ ]
VOLTAGE ADJUST. [ ]
Face Focus
GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS On [X] Off [ ] Y-AXIS On [ ] Off [ ]
DIRECTION Fwd. [ ] Rev. [X] DIRECTION Fwd. [ ] Rev. [ ]
TRAVEL SPEED, IPM 1 2 .0 TRAVEL SPEED, IPM [ ]
WIRE FEED On [X] Off [ ] INCH PER MINUTE 2 5 .0 2nd pass
BEAM ALIGNMENT NA FOCUS ADJUST. [ ]
HIGH VOLTAGE ADJUST. NOTED AVR Lock [ ] Unlock [X]

X-Ray Serial Number Beam Current Trace
Mag. Inspection Operator N. F. Wedell
Acceptance Standard MR&D Engineer J. C. Collins
Metallurgical Exam. Process Control

Table 2.1.4-VII

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS — Date 4-17-74

Part Number 603RJ00-11-3 H91 — Part Name Eng Test (EBW) — Material Type 10Ni (HY-180)

QC Serial Number F402754 — Tool Number — Mat'l. Thick 1.530

Filler Wire Type Low Alloy HY-180 10 Ni CR-MO-CO HT No. 51361 — Diameter .062

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 0	NA
Seconds: X 15 30 60 120	Seconds: X 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X	Y	FREQUENCY, KC		RANGE	
ATTENUATION, Db		METER RANGE		METER READING	

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 5 0	1 2 .0
Pass 2	1 4 0		1 2 .0
Pass 3			

FOCUS CURRENT METER: 1 - 5 .2 2 DC Amps.
2 - 5 .8 0

GUN FILAMENT METER: 0 6 8 AC Amps.

FILAMENT ADJUST POT.: 0 7 6

SKETCH OF JOINT

.5" backup with .06" x .187" groove.

TYPE OF JOINT: Butt

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On Off

METER, AC VOLTS

VOLTAGE ADJUST.

GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS	On X	Off	Y-AXIS	On / Off
DIRECTION	Fwd.	Rev. X	DIRECTION	Fwd. / Rev.
TRAVEL SPEED, IPM	1 2 .0		TRAVEL SPEED, IPM	

WIRE FEED	On X Off	INCH PER MINUTE	2 5 .0
BEAM ALIGNMENT		FOCUS ADJUST.	5 .2 2
HIGH VOLTAGE ADJUST.	NOTED	AVR	Lock / Unlock X

X-Ray Serial Number

Mag. Inspection

Acceptance Standard

Metallurgical Exam.

Beam Current Trace

Operator N. E. Wedell

MR&D Engineer J. C. Collins

Process Control

Table 2.1.4-VIII

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS — Date 4-17-74
Part Number 603R100-11-3 H92 — Part Name Eng Test (EBW) — Material Type 10Ni (HY-180)
Serial Number F-402753 — Tool Number — Mat'l. Thick 1.560
Filler Wire Type Low Alloy HY-180 10 Ni CR-MO-CO HT No. 51361 — Diameter .062

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 .0	NA
Seconds: 10 15 30 60 120	Seconds: 10 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X [ ] Y [ ] — FREQUENCY, KC [ ] — RANGE [ ]
ATTENUATION, Db [ ] — METER RANGE [ ] — METER READING [ ]

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 6 0	4 5 .0	1 2 .0
Pass 2	1 4 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER 1 - 5 .2 2 DC Amps.
2 - 5 .8 5
GUN FILAMENT METER 0 6 8 AC Amps.
FILAMENT ADJUST POT. 0 7 6

SKETCH OF JOINT

.5" backup with .06" x .187" groove

TYPE OF JOINT Butt

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On [ ] Off [X]
METER, AC VOLTS [ ]
VOLTAGE ADJUST. [ ]
Face Focus
GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS On [X] Off [ ] — Y-AXIS On [ ] Off [ ]
DIRECTION Fwd. [ ] Rev. [X] — DIRECTION Fwd. [ ] Rev. [ ]
TRAVEL SPEED, IPM 1 2 .0 — TRAVEL SPEED, IPM [ ]
WIRE FEED On [X] Off [ ] — INCH PER MINUTE 2 5 .0
BEAM ALIGNMENT NA — FOCUS ADJUST. [ ]
HIGH VOLTAGE ADJUST. NOTED — AVR Lock [ ] Unlock [X]

X-Ray Serial Number
Mag. Inspection
Acceptance Standard
Metallurgical Exam.

Beam Current Trace
Operator N. E. Wedell
MR&D Engineer J. C. Collins
Process Control

Table 2.1.4-IX

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS — Date 4-17-74

Part Number 603R100-11-3 H93 — Part Name Eng Test (EBW) — Material Type 10 Ni

QC Serial Number 402752 — Tool Number — Mat'l. Thick 1.550

Filler Wire Type Low Alloy HY-180 10 Ni CR-MO-CO HT No. 51361 — Diameter .062

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 .0	NA
Seconds: X 15 30 60 120	Seconds: X 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X	Y	FREQUENCY, KC		RANGE	
ATTENUATION, Db		METER RANGE		METER READING	

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 5 .0	1 2 .0
Pass 2	1 4 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER	GUN FILAMENT METER	FILAMENT ADJUST POT.
1 - 5 .2 2 DC Amps. 2 - 5 .9 0	0 6 8 AC Amps.	0 7 6

SKETCH OF JOINT

.5" backup with .06" x .187" groove.

TYPE OF JOINT: Butt

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS	On [ ] Off [X]
METER, AC VOLTS	
VOLTAGE ADJUST.	
Face Focus	
GUN-TO-WORK DISTANCE, Inches	3 .5

OPERATOR'S STATION CONTROL

X-AXIS	On [X] Off [ ]	Y-AXIS	On [ ] Off [ ]
DIRECTION	Fwd. [ ] Rev. [X]	DIRECTION	Fwd. [ ] Rev. [ ]
TRAVEL SPEED, IPM	1 2 .0	TRAVEL SPEED, IPM	
WIRE FEED	On [X] Off [ ]	INCH PER MINUTE	2 5 .0
BEAM ALIGNMENT	NA	FOCUS ADJUST.	
HIGH VOLTAGE ADJUST.	NOTED	AVR	Lock [ ] Unlock [X]

X-Ray Serial Number — Beam Current Trace

Mag. Inspection — Operator N. E. Wedell

Acceptance Standard — MR & D Engineer J. C. Collins

Metallurgical Exam. — Process Control

Table 2.1.4-X

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS | Date 4-20-74

Part Number 603R100-11-3 H94 | Part Name Eng Test (EBW) | Material Type 10Ni (HY-180)

QC Serial Number 402496 | Tool Number | Mat'l. Thick 1.6

Filler Wire Type Low Alloy HY-180 10 Ni CR-MO-CO HT No. 51361 | Diameter .062

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 .0	NA
Seconds	Seconds	Slope	Slope	Run
X 15 30 60 120	X 15 30 60 120	2 0 2	0 1 7	

OSCILLATOR

AXIS X [ ] Y [ ] | FREQUENCY, KC [ ] | RANGE [ ]

ATTENUATION, Db [ ] | METER RANGE [ ] | METER READING [ ]

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 5 .0	1 2 .0
Pass 2	1 4 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER 1 - 5 .2 2 DC Amps. | GUN FILAMENT METER 0 6 8 AC Amps. | FILAMENT ADJUST POT. 0 7 6

SKETCH OF JOINT

.5" backup with .06" x .187" groove.

TYPE OF JOINT: Butt

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On [ ] Off [X]

METER, AC VOLTS [ ]

VOLTAGE ADJUST. [ ]

Face Focus

GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS On [X] Off [ ] | Y-AXIS On [ ] Off [X]

DIRECTION Fwd. [ ] Rev. [X] | DIRECTION Fwd. [ ] Rev. [ ]

TRAVEL SPEED, IPM 1 2 .0 | TRAVEL SPEED, IPM [ ]

WIRE FEED On [X] Off [ ] | INCH PER MINUTE 2 5 .0

BEAM ALIGNMENT NA | FOCUS ADJUST. [ ]

HIGH VOLTAGE ADJUST. NOTED | AVR Lock [ ] Unlock [X]

X-Ray Serial Number ______ | Beam Current Trace

Mag. Inspection ______ | Operator N. E. Wedell

Acceptance Standard ______ | MR&D Engineer J. C. Collins

Metallurgical Exam. ______ | Process Control ______

Table 2.1.4-XI

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS | Date 4-23-74

Part Number 603R 100-11-3 H-95 | Part Name Eng Test (EBW) | Material Type 10 Ni

QC Serial Number 402495 | Tool Number | Mat'l. Thick 1.6

Filler Wire Type Low Alloy HY-180 | Diameter .062

10 Ni CR-MO-CO

HT No. 51361

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 1	4 5 .2	2 6 .0	NA
Seconds	Seconds	Slope	Slope	Run
X 15 30 60 120	X 15 30 60 120	2 0 2	0 1 7	

OSCILLATOR

AXIS X ☐ Y ☐ | FREQUENCY, KC | RANGE

ATTENUATION, Db | METER RANGE | METER READING

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 5 .0	1 2 .0
Pass 2	1 4 0	2 2 .0	1 2 .0
Pass 3			

SKETCH OF JOINT

FOCUS CURRENT METER	GUN FILAMENT METER	FILAMENT ADJUST POT.	TYPE OF JOINT
1 - 5 .2 2 DC Amps.	0 6 8 AC Amps.	0 7 6	Butt
2 - 5 .9 5			

GUN ELEMENTS

GUN TYPE,	KV	6 0	BIAS	On ☐	Off X
FILAMENT,	MA	5 0 0	METER, AC VOLTS		
CATHODE,	MA	7 5 0	VOLTAGE ADJUST.		
ANODE,	KV/MA	7 5 0	Face Focus		
SPACER,	Inches	.1 0 0	GUN-TO-WORK DISTANCE, Inches	3 .5	

OPERATOR'S STATION CONTROL

X-AXIS	On X	Off ☐	Y-AXIS	On ☐	Off ☐
DIRECTION	Fwd. ☐	Rev. X	DIRECTION	Fwd. ☐	Rev. ☐
TRAVEL SPEED, IPM	1 2 .0		TRAVEL SPEED, IPM		
WIRE FEED	On X	Off ☐	INCH PER MINUTE	2 5 .0	
BEAM ALIGNMENT			FOCUS ADJUST.	5 .2 2	
HIGH VOLTAGE ADJUST.	NOTED		AVR	Lock ☐	Unlock ☐

X-Ray Serial Number

Mag. Inspection

Acceptance Standard

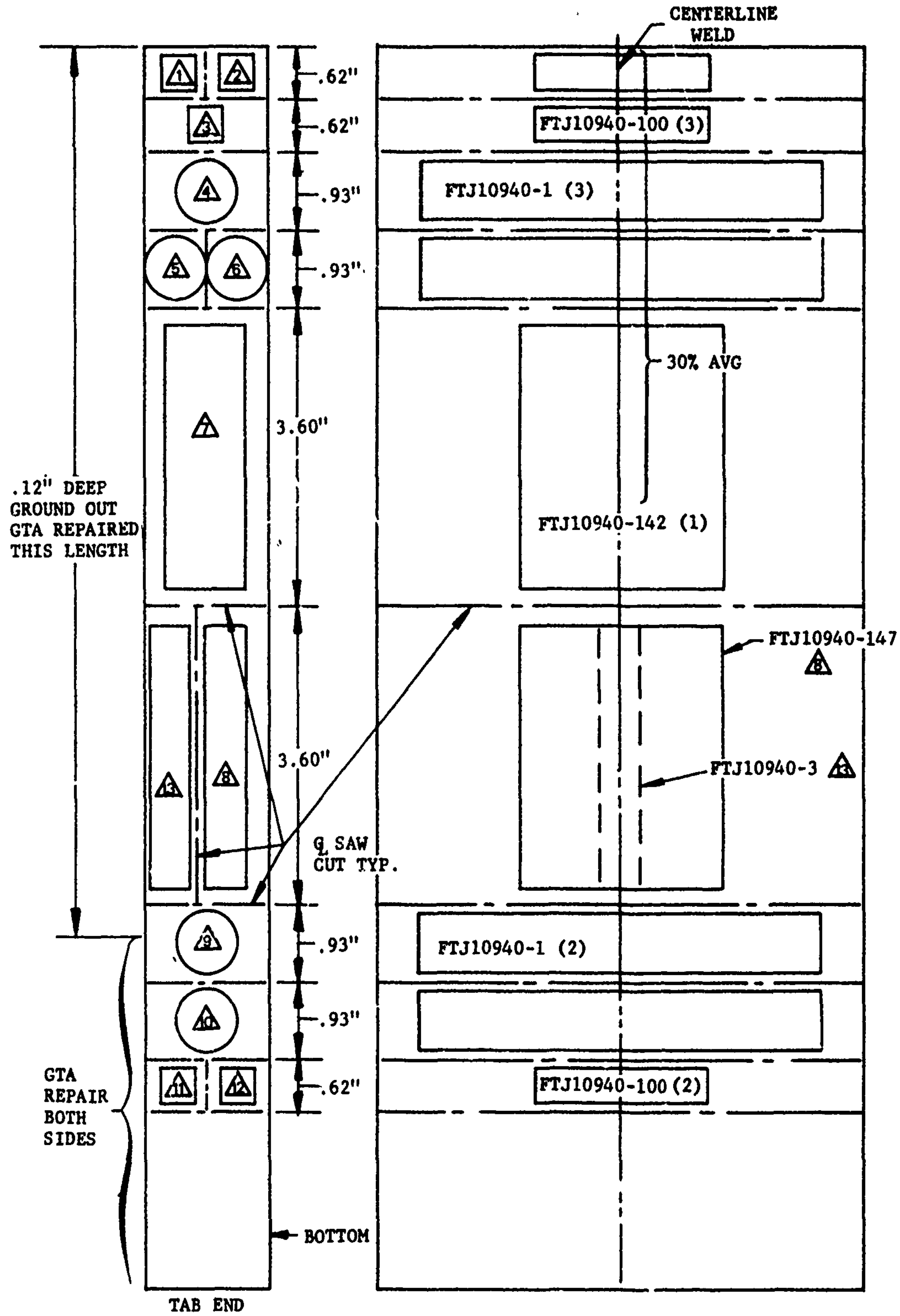
Metallurgical Exam.

Beam Current Trace

Operator N. E. Wedell

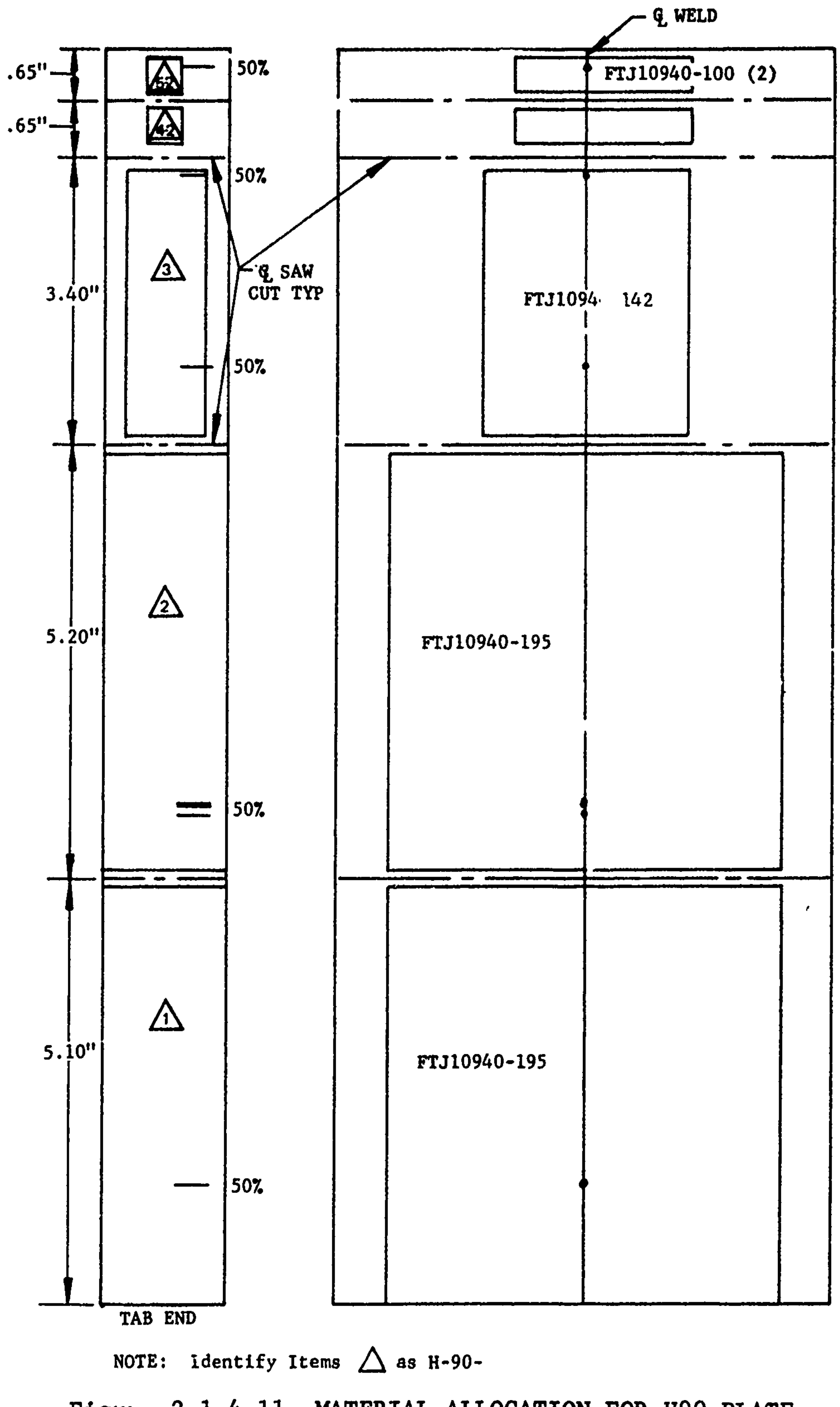
MR & D Engineer J. C. Collins

Process Control



NOTE: Identify Item △ as H-89-

Figure 2.1.4-10 MATERIAL ALLOCATION FOR H89 PLATE ELECTRON BEAM WELD



NOTE: identify Items △ as H-90-

Figu: 2.1.4-11 MATERIAL ALLOCATION FOR H90 PLATE ELECTRON BEAM WELD

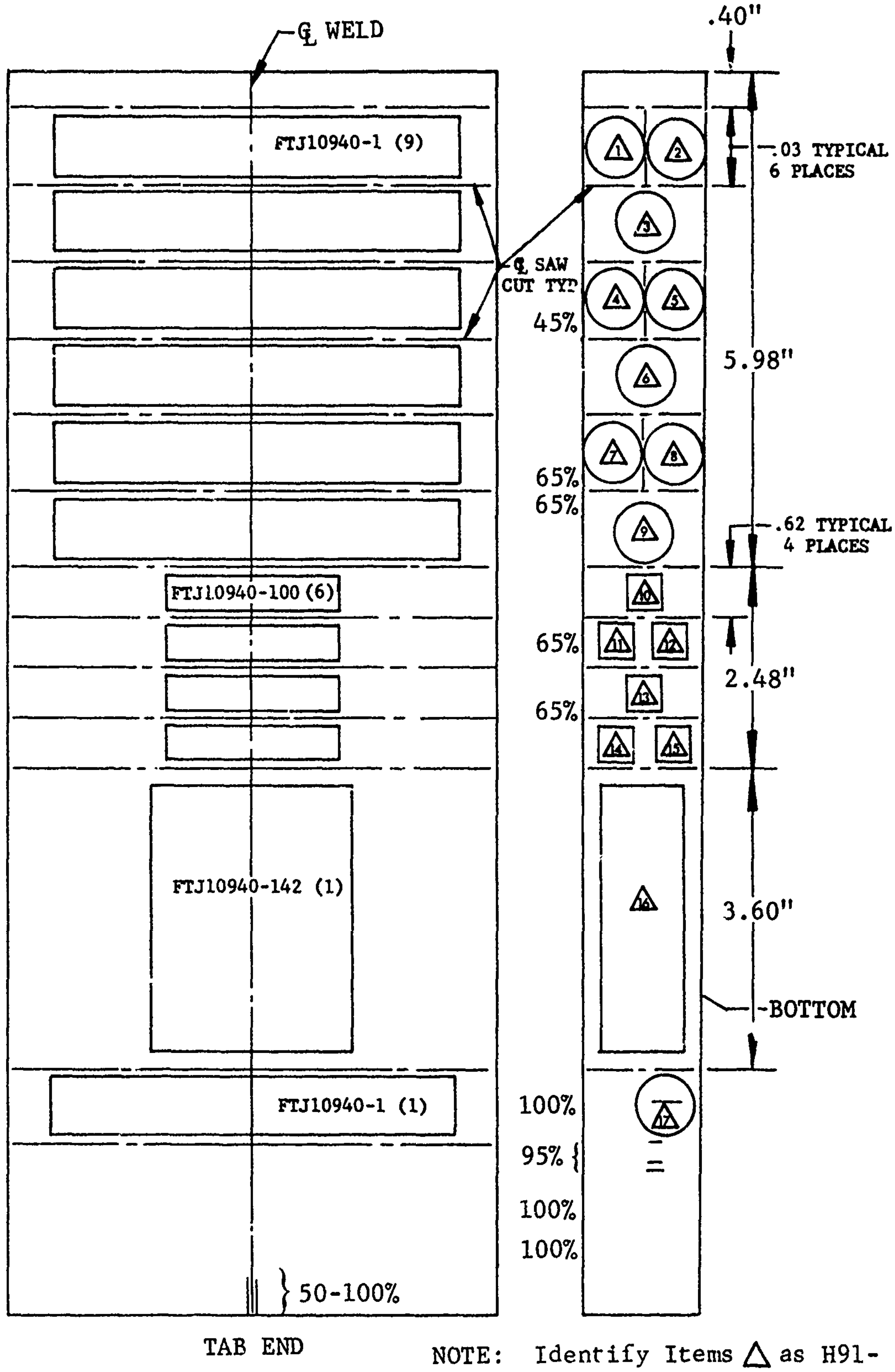
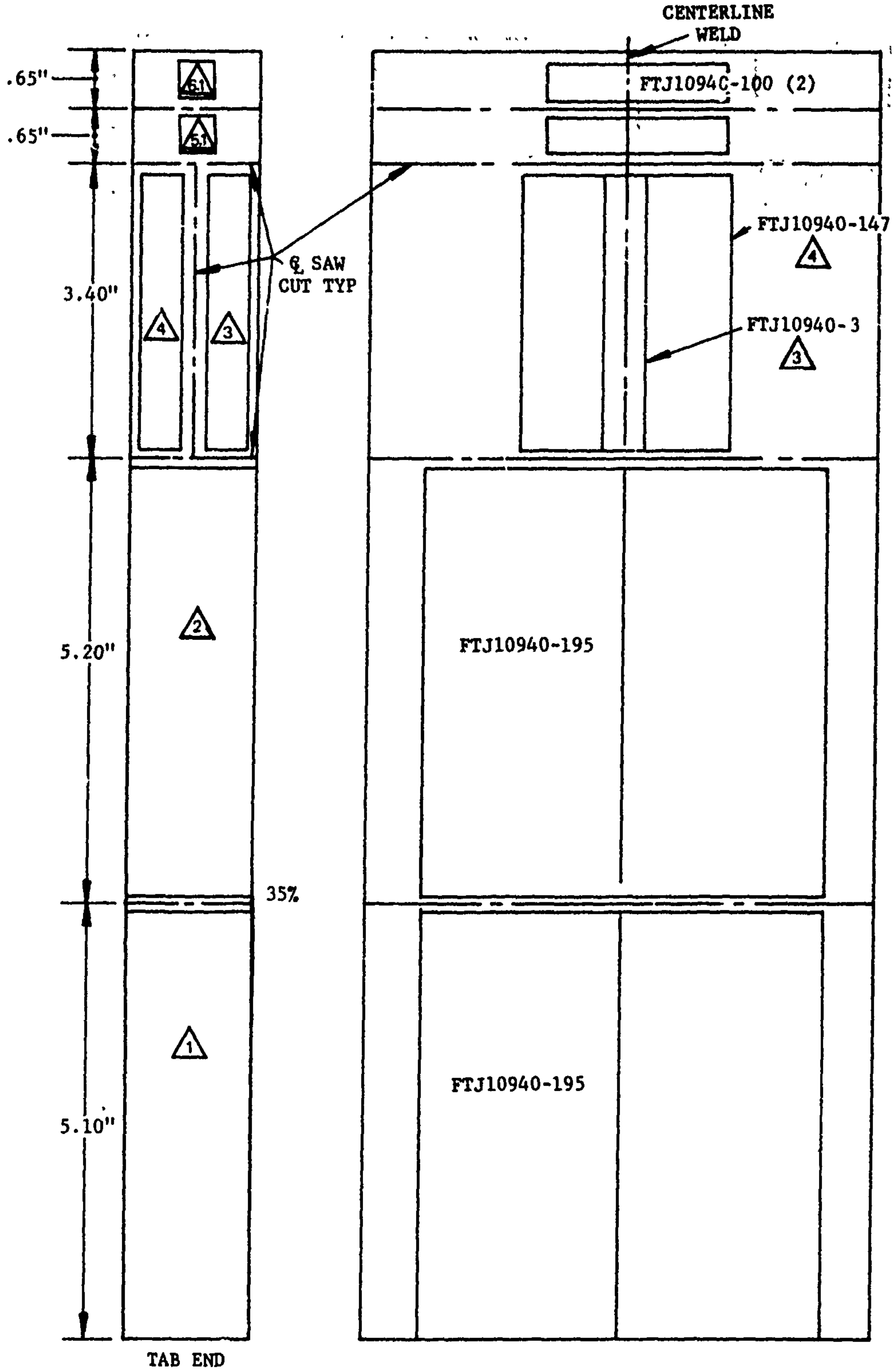
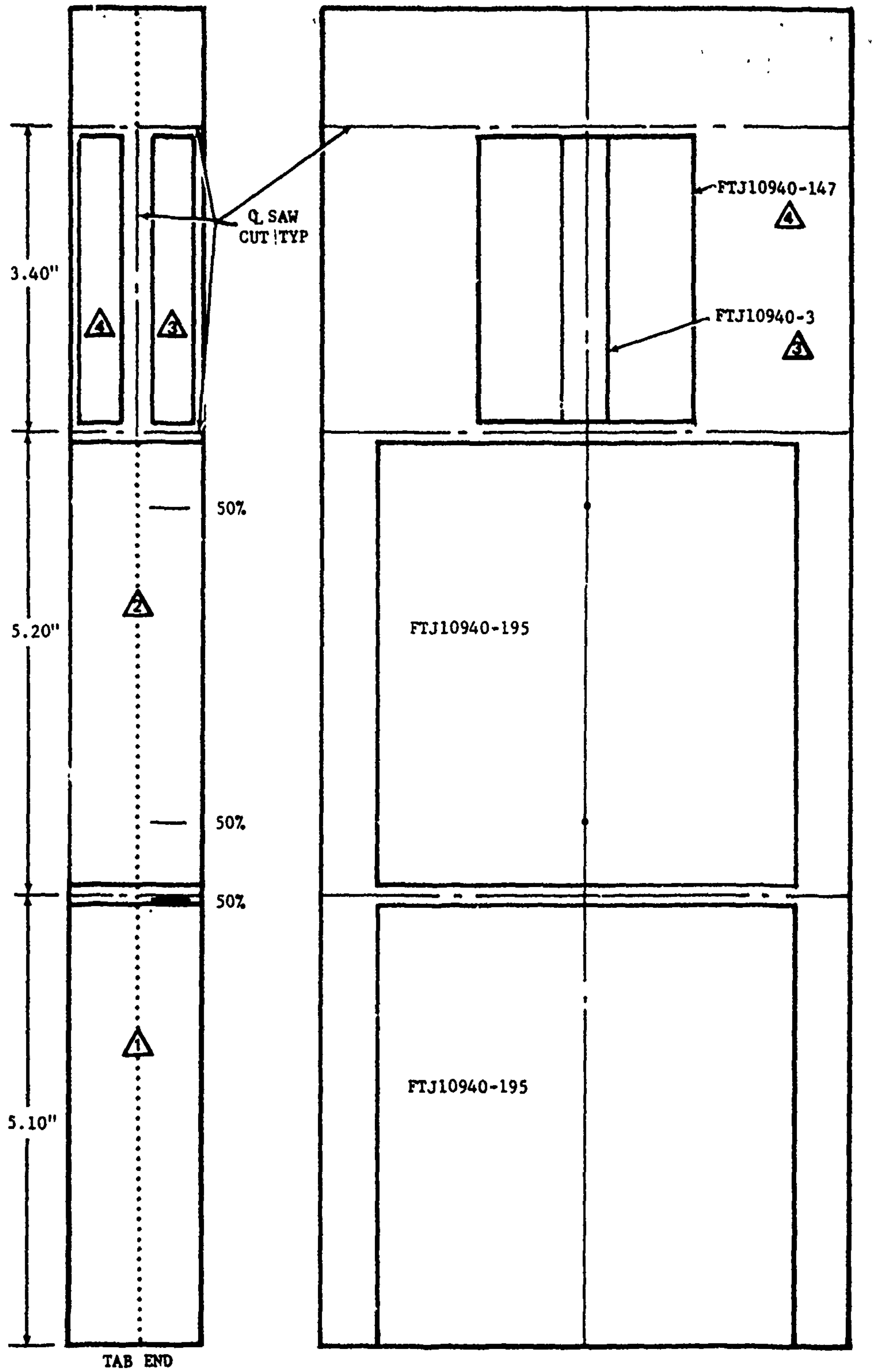


Figure 2.1.4-12 MATERIAL ALLOCATION FOR H91 PLATE ELECTRON BEAM WELD



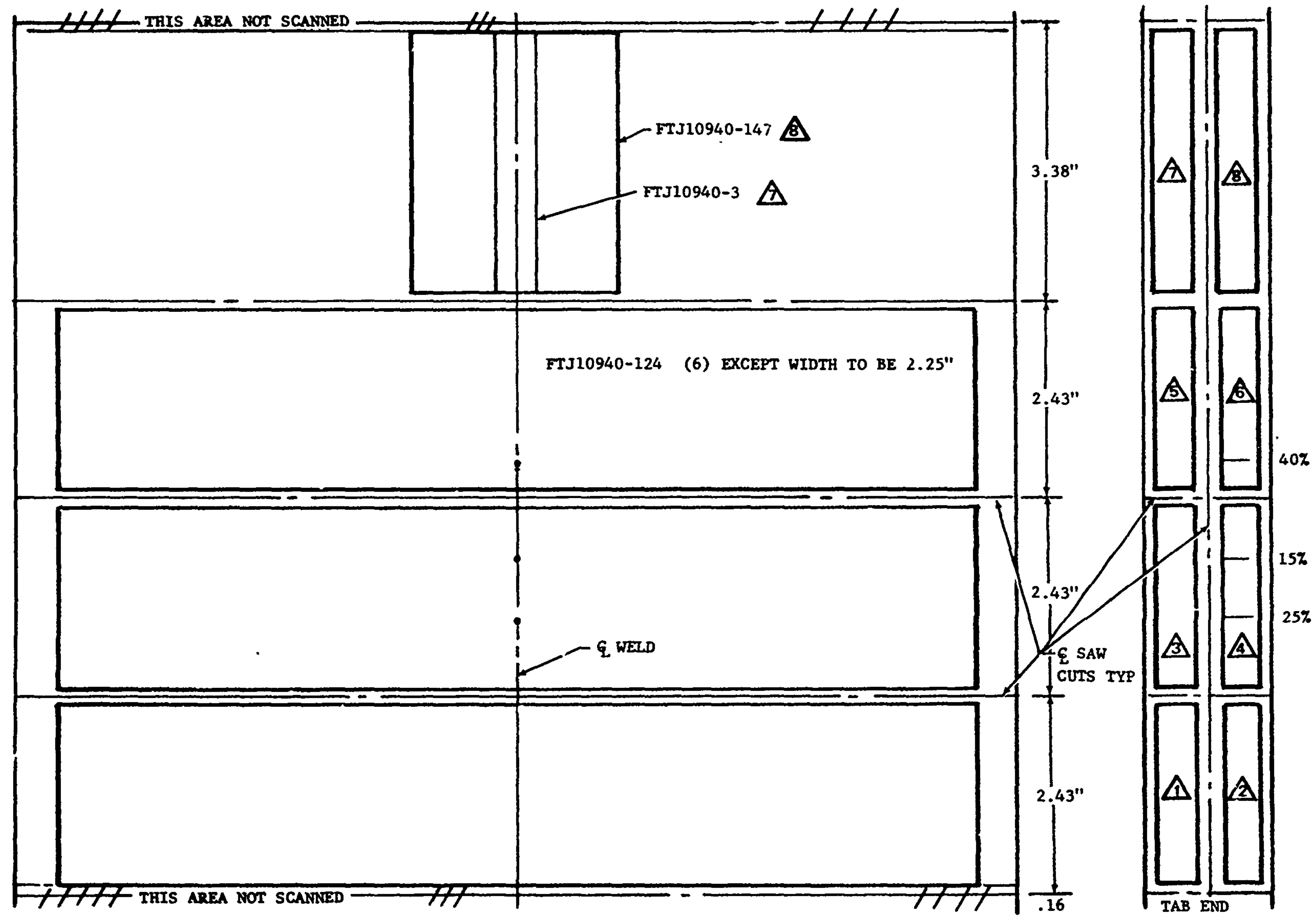
NOTE: Identify Item as H-92-

Figure 2.1.4-13 MATERIAL ALLOCATION FOR H92 PLATE ELECTRON BEAM WELD



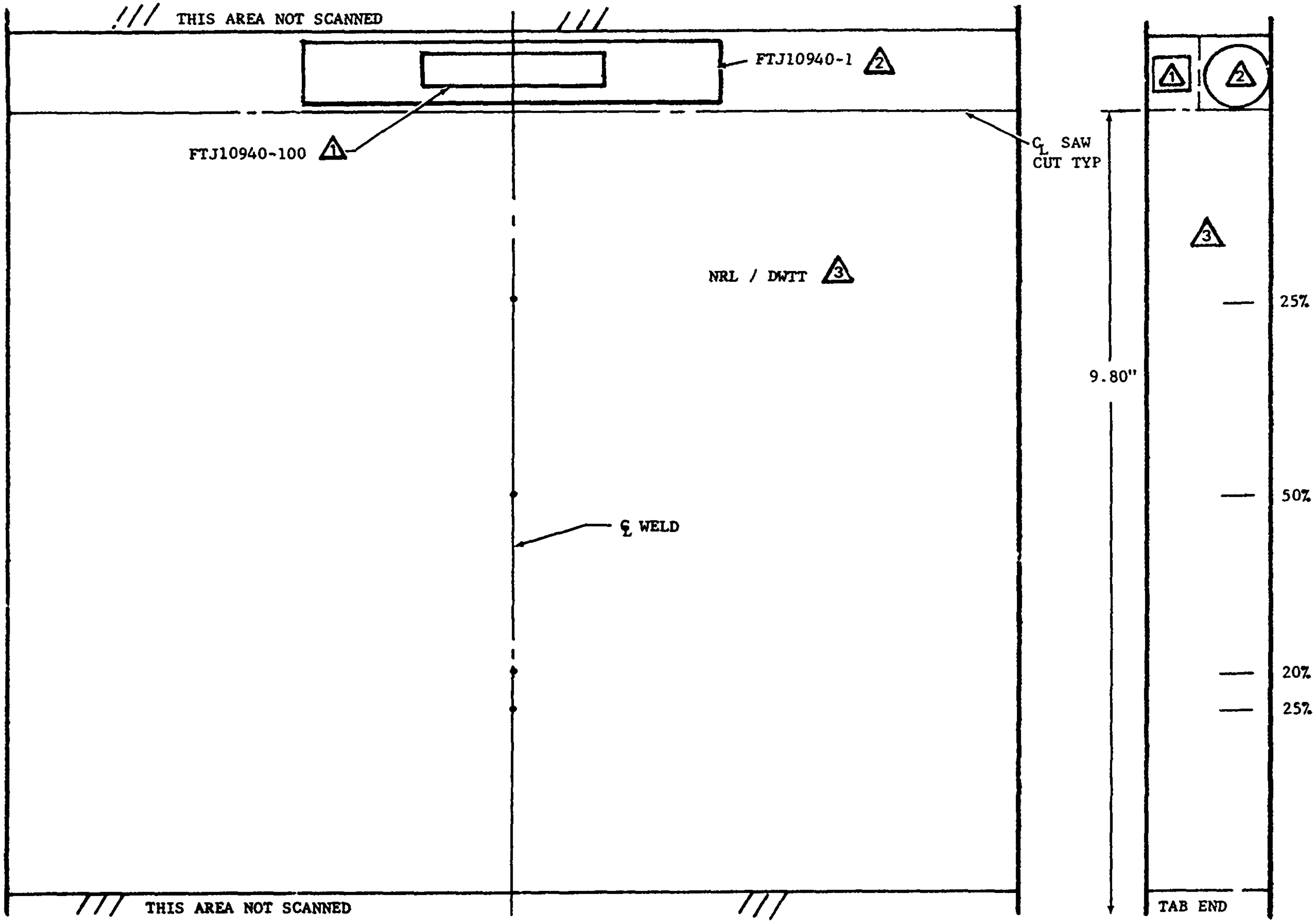
NOTE: Identify Item Δ as H93 ----

Figure 2.1.4-14 MATERIAL ALLOCATED FOR H93 PLATE ELECTRON BEAM WELD



NOTE: Identify Items △ as H94 ----

Figure 2.1.4-15 MATERIAL ALLOCATED FOR H94 PLATE ELECTRON BEAM WELD



NOTE: Identify Items △ as H-94 ----

Figure 2.1.4-16 MATERIAL ALLOCATED FOR H95 PLATE ELECTRON BEAM WELD

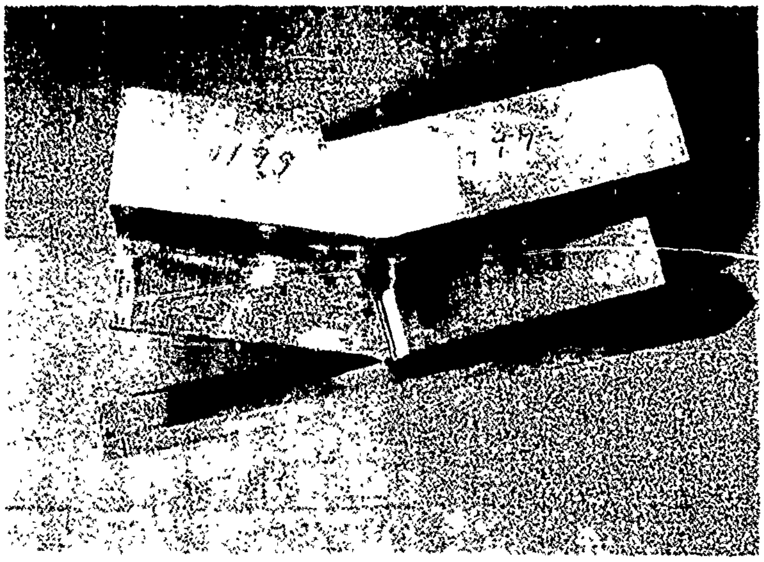


Figure 2.1.4-17 SIMULATED UPPER CAP TEE SECTION

Table 2.1.4-XII

ELECTRON BEAM WELDING SCHEDULE

Schedule Number ______ Date 5-1-74
Part Number H-99 Part Name Producibility Test Material Type 10 Ni
Serial Number Tee Section Tool Number T17315 Mat'l. Thick 1.83
Filler Wire Type Low Alloy (Hy-180) Diameter .062
10 Ni CR-MO-CO
Ht. No. 51361

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 2	2 6 0	NA
Seconds	Seconds	Slope	Slope	Run
X 0 15 30 60 120	X 0 15 30 60 120	2 0 2	0 1 7	

OSCILLATOR

AXIS X ☐ Y ☐ FREQUENCY, KC ☐ RANGE ☐
ATTENUATION, Db ☐ METER RANGE ☐ METER READING ☐

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 6 0	4 6 .0	1 2 .0
Pass 2	1 3 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER 1- 5 .2 2 DC Amps. GUN FILAMENT METER 0 6 8 AC Amps. FILAMENT ADJUST POT. 0 7 6

2- 5 .9 5

SKETCH OF JOINT

TYPE OF JOINT Butt tee

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On ☐ Off X
METER, AC VOLTS ☐
VOLTAGE ADJUST. ☐
Face Focus
GUN-TO-WORK DISTANCE, Inches 3 .5 (4.95)

OPERATOR'S STATION CONTROL

X-AXIS	On ☐ Off X	Y-AXIS	On X Off ☐
DIRECTION	Fwd. ☐ Rev. ☐	DIRECTION	Fwd. ☐ Rev. X
TRAVEL SPEED, IPM		TRAVEL SPEED, IPM	1 2 .0
WIRE FEED	On ☐ Off X	INCH PER MINUTE	0 0 0
BEAM ALIGNMENT	NA	FOCUS ADJUST.	5 2 2
HIGH VOLTAGE ADJUST.	NOTED	AVR	Lock ☐ Unlock X

X-Ray Serial Number ______
Mag. Inspection ______
Acceptance Standard ______
Metallurgical Exam. ______

Operator N. E. Wedell
MR&D Engineer J. C. Collins
Process Control ______

Table 2.1.4-XIII

ELECTRON BEAM WELDING SCHEDULE

Schedule Number				Date	5-2-74
Part Number	H-100	Part Name	Producibility Test	Material Type	10 Ni (Hy-180)
Serial Number		Tool Number	T17315	Mat'l. Thick	1.6
	Tee Section	Filler Wire Type	Low Alloy (Hy-180) 10 Ni CR-MO-CO Ht. No. 51361	Diameter	.062

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 0	NA
Seconds: 0 (X) 15 30 60 120	Seconds: 0 (X) 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X	Y	FREQUENCY, KC		RANGE	
ATTENUATION, Db		METER RANGE		METER READING	

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 6 0	4 6 .0	1 2 .0
Pass 2	1 3 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER	GUN FILAMENT METER	FILAMENT ADJUST POT.	TYPE OF JOINT
1- 5 .2 2 DC Amps.	0 6 8 AC Amps.	0 7 6	Tee butt with backup

2- 5 .9 5

SKETCH OF JOINT

GUN ELEMENTS

GUN TYPE,	KV	6 0	BIAS	On [ ] Off [X]
FILAMENT,	MA	5 0 0	METER, AC VOLTS	
CATHODE,	MA	7 5 0	VOLTAGE ADJUST.	
ANODE,	KV/MA	7 5 0		Face Focus
SPACER,	Inches	.1 0 0	GUN-TO-WORK DISTANCE, Inches	3 .5

OPERATOR'S STATION CONTROL

X-AXIS	On [ ] Off [ ]	Y-AXIS	On [X] Off [ ]
DIRECTION	Fwd. [ ] Rev. [ ]	DIRECTION	Fwd. [ ] Rev. [X]
TRAVEL SPEED, IPM		TRAVEL SPEED, IPM	1 2 .0
WIRE FEED	On [ ] Off [X]	INCH PER MINUTE	
BEAM ALIGNMENT		FOCUS ADJUST.	5 .2 2
HIGH VOLTAGE ADJUST.	NOTED	AVR	Lock [ ] Unlock [X]

X-Ray Serial Number			
Mag. Inspection		Operator	N. E. Wedell
Acceptance Standard		MR&D Engineer	J. C. Collins
Metallurgical Exam.		Process Control	

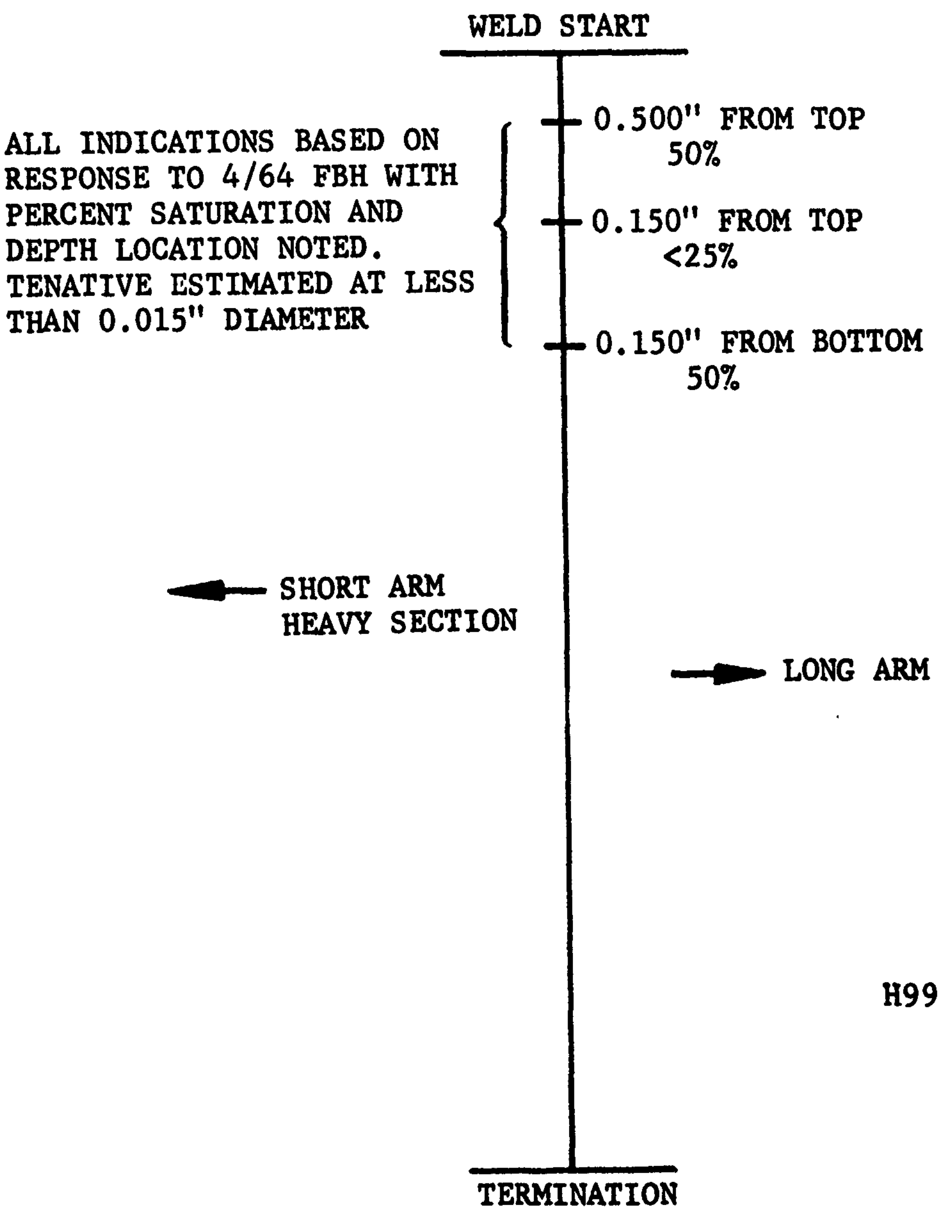
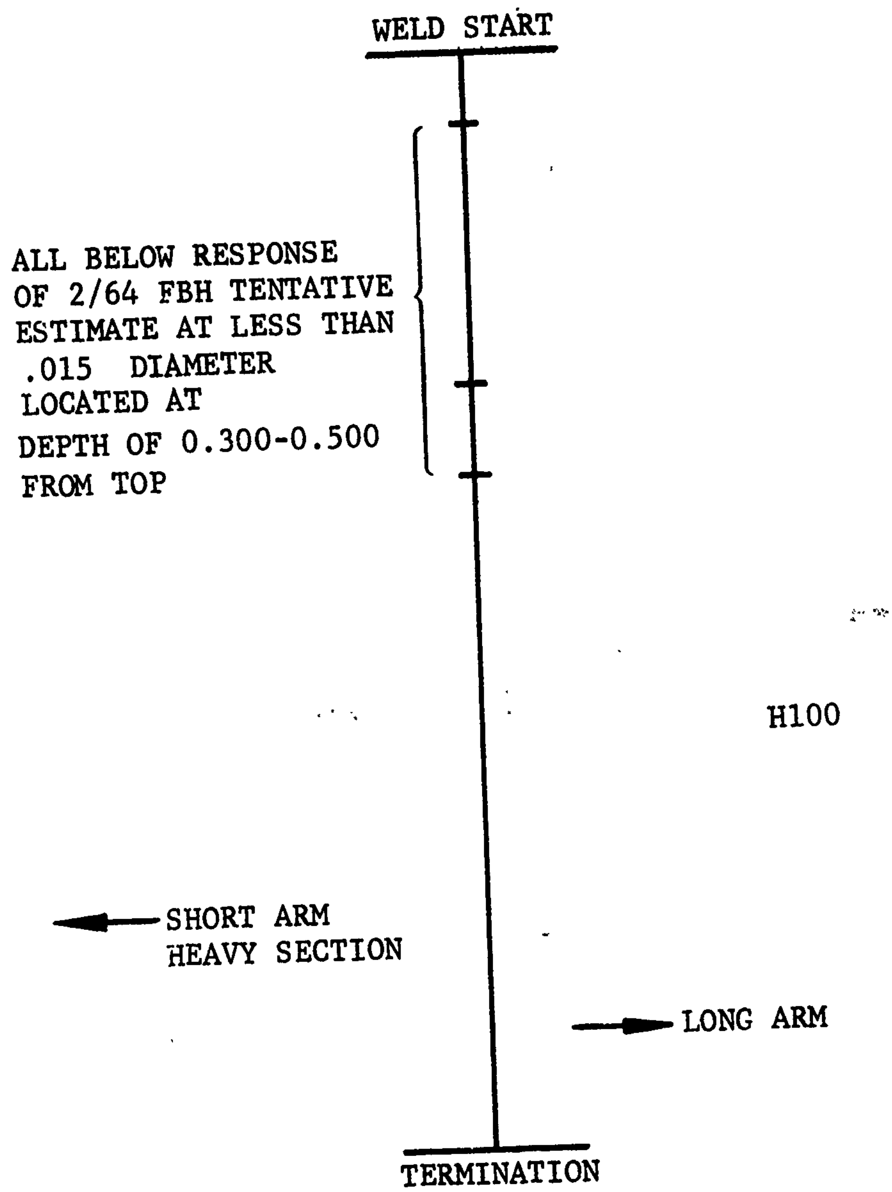
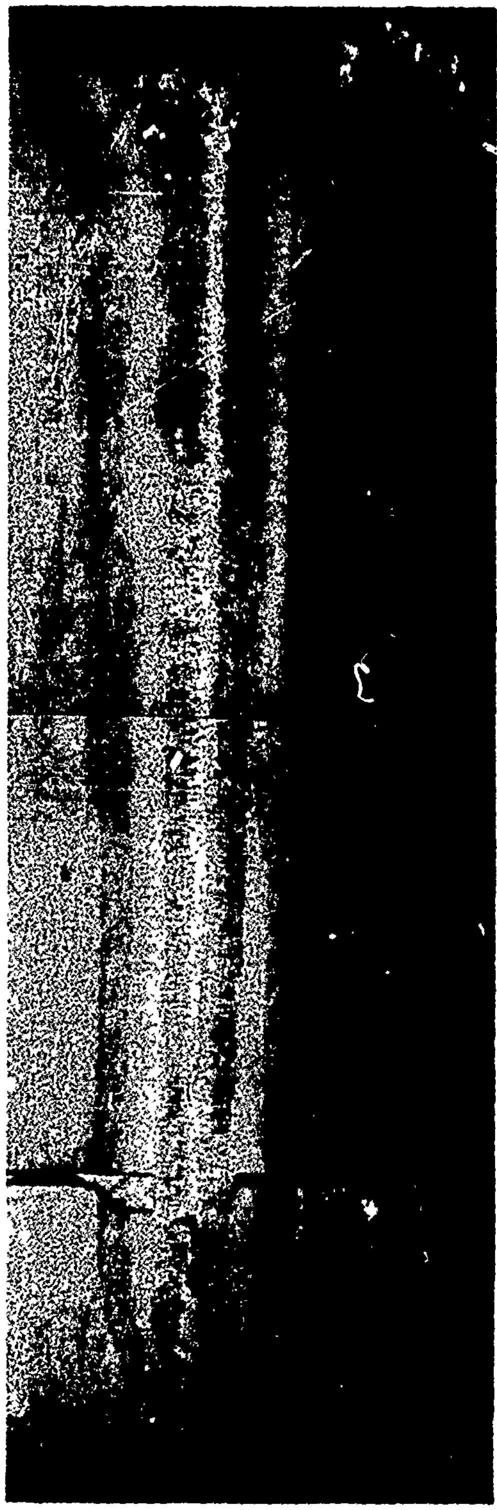


Figure 2.1.4-18 NDI ULTRASONIC INDICATIONS SIMULATED UPPER CAP H99 & H100 (Sheet 1) SHOWING FULL LENGTH OF WELD (FULL SCALE)



0.090" DEEP WELD REPAIR ALONG BOTTOM SURFACE
0.250" DEEP REPAIR 3/4"FROM TOP OF TERMINATION END

Figure 2.1.4-18 (Sheet 2)



Note shrinkage crack in backup bar material.

Figure 2.1.4-19 MACROGRAPH ON X7224091 CERTIFICATION TEST

Table 2.1.4-XIV

TENSILE PROPERTIES OF ELECTRON BEAM WELDS
TRANSVERSE TEST DIRECTION

PANEL & SERIAL NO.	DIA. OR GAUGE	WIDTH	AREA	YIELD POINT		ULTIMATE		ELONG-ATION*	RED. AREA	FAIL-URE
				POUNDS	PSI	POUNDS	PSI			
H89-4	.501		.1971	35,100	178,000	37,950	192,500	16	71.1	BM
H89-5	.506		.2011	35,500	176,500	38,600	192,000	16	62.0	WELD
H89-6	.601		.1971	35,000	177,500	37,960	192,500	16	70.3	BM
H89-9	.499		.1956	34,400	175,900	37,900	193.800	4	11.3	WELD
H89-10	.505		.2002	34,800	173,800	38,350	191,600	16	71.2	BM
H91-1	.505		.2003	36,000	179,700	38,950	194,400	16	69.2	BM
H91-2	.503		.1987	35,250	177,400	38,500	193,700	15	71.1	BM
H91-3	.503		.1987	35,250	177,400	38,750	195,000	16	70	BM
H91-4	.506		.2011	36,100	179,500	38,850	193,100	16	69.3	BM
H91-5	.505		.2003	35,500	177,200	38,600	192,700	16	70.7	BM
H91-6	.508		.2026	35,250	174,000	39,700	196,000	20	71.5	BM
H91-7	.500		.1964	35,200	179,200	38,250	194,700	15	70.6	BM
H91-8	.502		.1979	35,200	177,800	38,400	194,000	16	69.6	BM
H91-9	.506		.2011	34,700	172,600	38,750	192,700	18	71.3	BM
H91-17	.501		.1971	35,300	179,000	38,700	196,300	16	70.9	BM
H95-2	.507		.2019	36,800	182,300	39,300	194,650	16	66.8	BM

*PERCENT IN 2.0 INCHES GAP LENGTH.

Note failure in H89-5 and H89-9

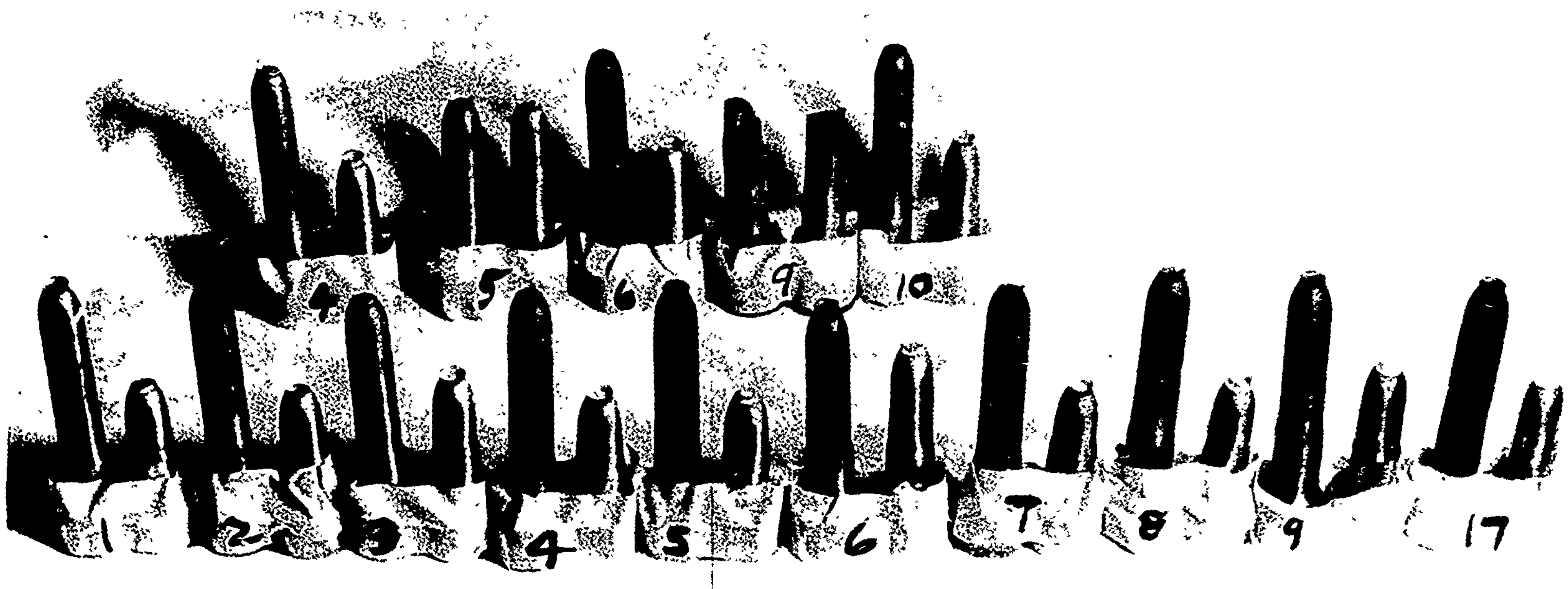


Figure 2.1.4-20 TENSILE SPECIMEN FAILURES FROM PLATE H89 AND H91

Note the size of the porosity
(Mag approximately 20X)

Figure 2.1.4-21 H89-5 FAILURE

Note appearance of fracture and the
cracks in the Test Section (Mag unknown)

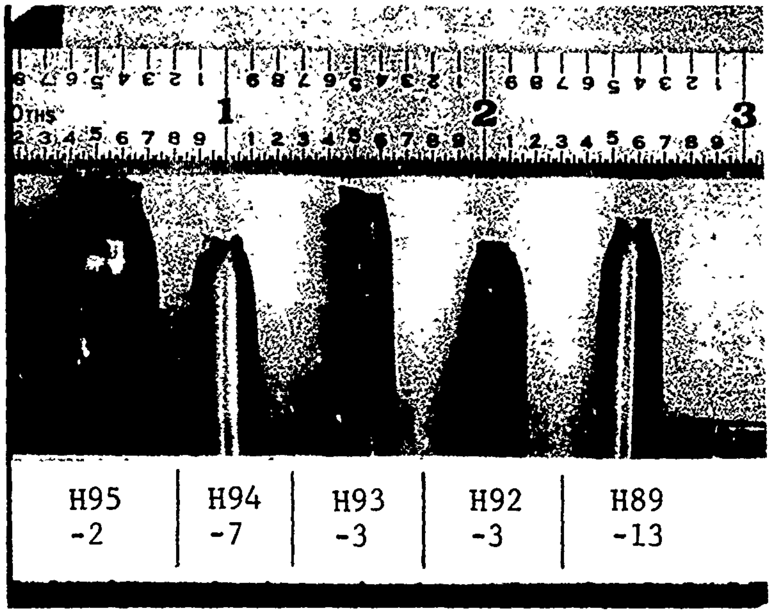
Figure 2.1.4-22 H89-9 FAILURE

Table 2.1.4-XV

TENSILE PROPERTIES OF ELECTRON BEAM
WELDS - LONGITUDINAL DIRECTION

PANEL & SERIAL NO.	DIA. OR GAUGE	WIDTH	AREA	YIELD POINT		ULTIMATE		ELONG-ATION*	RED. AREA
				POUNDS	PSI	POUNDS	PSI		
H89-13	.2480		.0483	8200	169.8	9340	193.4	16.0	73.3
H92-3	.2528		.0502	8740	174.1	9860	196.4	15.0	69.7
H93-3	.2528		.0502	8630	171.9	9840	196.0	14.0	61.0
H94-7	.2522		.0500	8540	170.8	9700	194.0	15.0	62.2

*PERCENT IN 1.0 INCH GAGE LENGTH.



H95-2 is shown for comparison with transverse specimen size and failure appearance.

Figure 2.1.4-23 LONGITUDINAL EB WELD SPECIMEN

Miniature specimens were used in order to maintain the greatest percentage of EB weld possible in the test section. The size can be compared with the full size H95-2 specimen which is included in the photograph.

Sixteen Charpy V-Notch impact test specimens have been tested at 0°F and the data generated is shown in Table 2.1.4-XVI. Specimens were located in known areas of defects, both acceptable and unacceptable. Photographs of the fracture from weld plates H-89 and H-91 are shown in Figures 2.1.4-24, -25 and -26 and minor defects can be seen in the fractures. Figure 2.1.4-27 is a photograph of the fractures of specimens removed from an unacceptable GTA weld repair area, and the results at 0°F are unusually good considering the magnitude of the weld defect.

The effect of notch location with respect to weld line was also explored as noted in Table 2.1.4-XVI. Figure 2.1.4-28 shows the location of the Charpy notch with respect to the weld zones and the results obtained. Figure 2.1.4-29 is a photograph of the fracture face at various weld zones.

Macrographs of the weld joints in panels H89 and H91 are shown in Figures 2.1.4-30 and 31. Note that panel H89 had a weld repair made along the bottom of the plate which is noted in the weld schedule shown in Table 2.1.4-V. The macros for panel H91 show the addition of a cosmetic weld pass along the upper surface. All test specimens were removed as near these surfaces as possible to determine the effect, if any, on test data. If differences exist, they do not appear significant.

One crack propagation rate test on the EB welds has been completed; Specimen H89-8. The specimen was tested in dry air at an R = 0.1 at a fast cyclic rate. A complete evaluation of the data has not been completed, but a cursory examination indicates almost the same propagation rate as was noted for GTA welds under the same conditions. Actual rate of growth appears to be slower than that in the base metal.

2.1.4.7 Corrosion Protection

A change to finish requirements for 10 Nickel steel has been made to delete the use of cadmium plating. This change was coordinated with ADPO. The finish requirement now is to apply MIL-C-27725 fuel tank corrosion coating for fuel areas and 2 coats of MIL-P-23377 epoxy-polyamide for all other areas.

Table 2.1.4-XVI

EB WELD 10 NI STEEL - CHARPY V-NOTCH
IMPACT AT $0^{o}F$

NOTCH LOCATED AT CENTER OF EB WELD UNLESS OTHERWISE NOTED

	DEPTH RAD.	W	TH	RADIUS NOTCH	FOOT/ POUNDS	
H91-10	.0785	.3947	.3945	.012	63.5	
11	.0787	.3947	.3940	.012	81.5	
12	.0785	.3948	.3944	.012	60.0	DID NOT RESET DIAL
13	.0788	.3948	.3943	.012	72.0	
14	.0800	.3946	.3943	.0125	71.0	
15	.0790	.3946	.3944	.0125	69.0	
H89-1	.0797	.3946	.3944	.0105	49.5	
2	.0792	.3947	.3947	.0105	54.5	
3	.0789	.3946	.3943	.011	80.0	
H95-1	.0795	.3939	.3940	.012	66.0	
H90-4.2	.0795	.3938	.3939	.012	63.0	NOTCH LOCATED IN
5.2	.0805	.3940	.3938	.012	68.5	VARIOUS AREAS OF THE
5.1	.0797	.3938	.3942	.012	85.0	HAZ AND WELD INTERFACE
6.1	.0795	.3940	.3940	.012	82.5	SEE FIGURE 2.1.4-
H89-11	.0795	.3937	.3940	.012	28.0	LOCATED IN UNACCEPTABLE
-12	.0785	.3940	.3940	.0105	17.0	GTA WELD REPAIR AREA

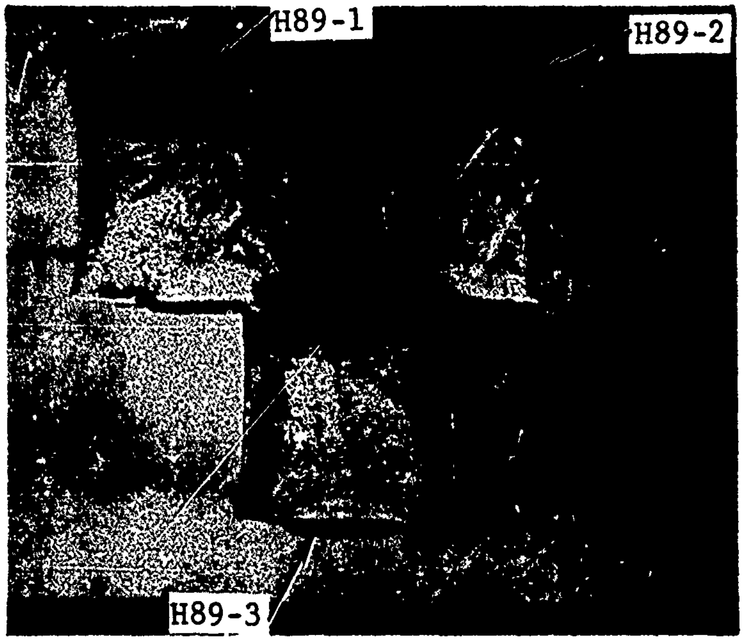


Figure 2.1.4-24 CHARPY IMPACT FRACTURES - PANEL H89

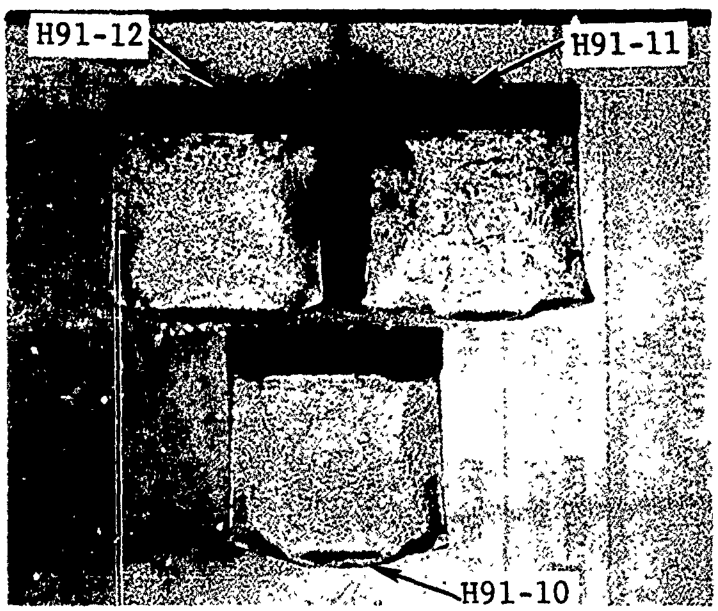


Figure 2.1.4-25 CHARPY IMPACT FRACTURES - PANEL H91

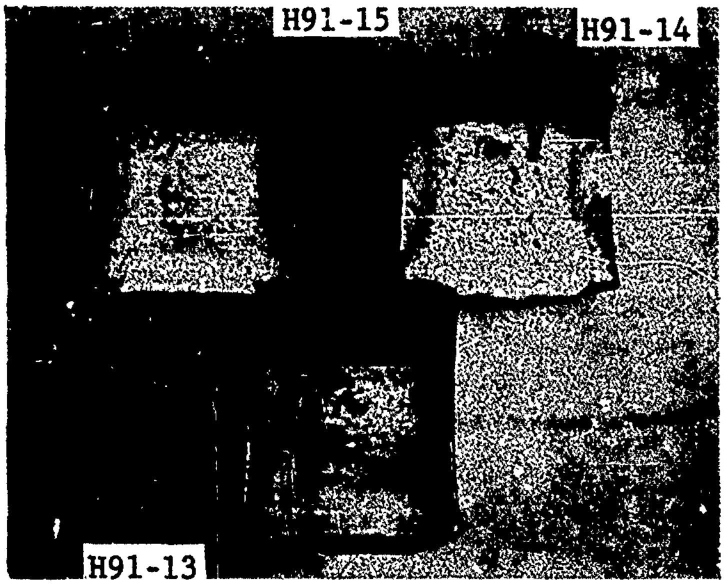
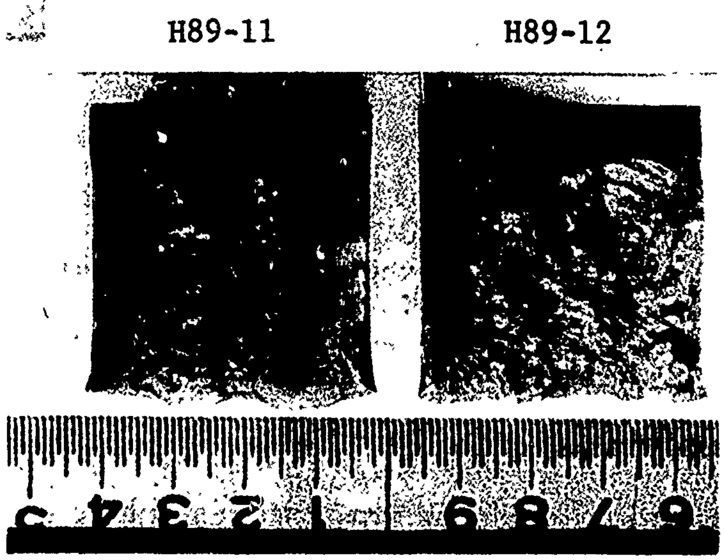
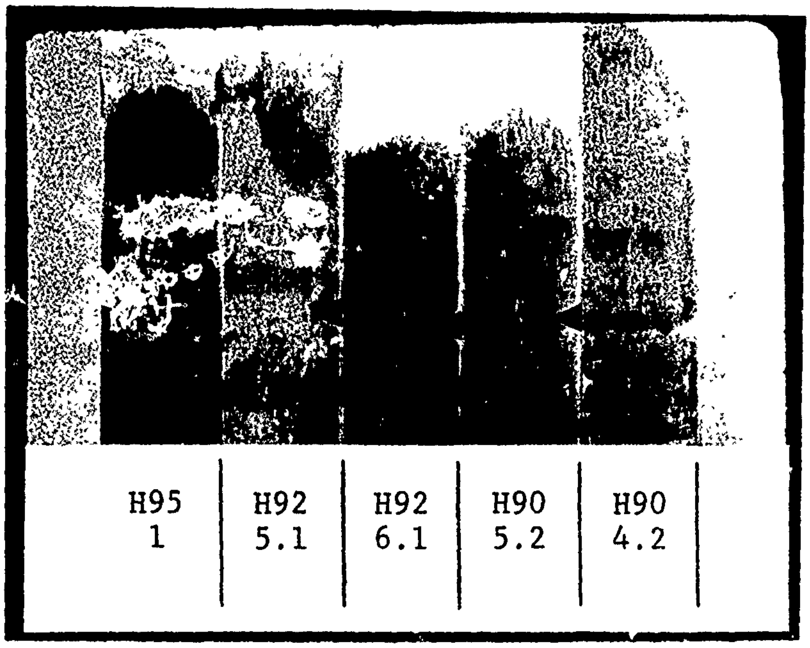


Figure 2.1.4-26 CHARPY IMPACT FRACTURES
- PANEL H91



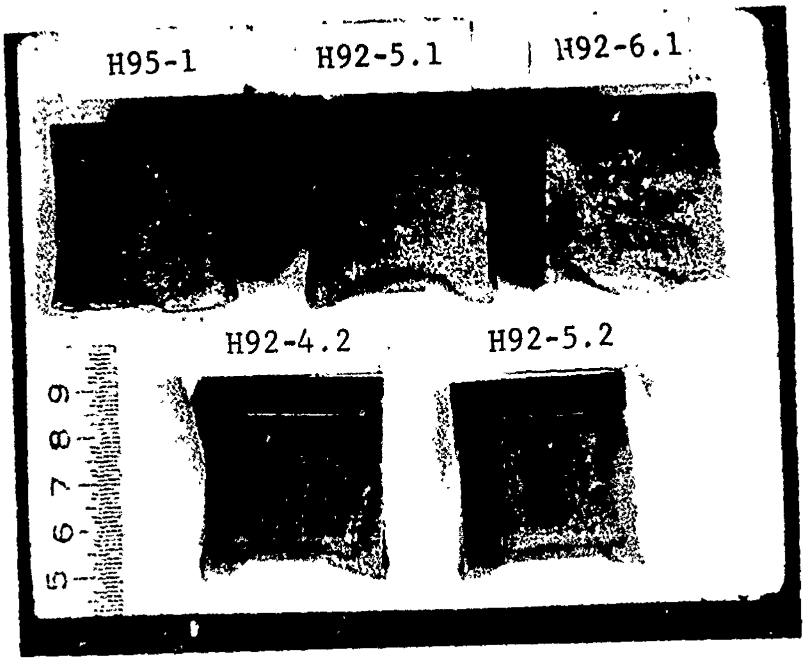
Note the dentridic structure and the coarseness of the fracture as compared to previous fractures.

Figure 2.1.4-27 CHARPY V-NOTCH FRACTURE FACE FROM UNACCEPTABLE GTA WELD REPAIR



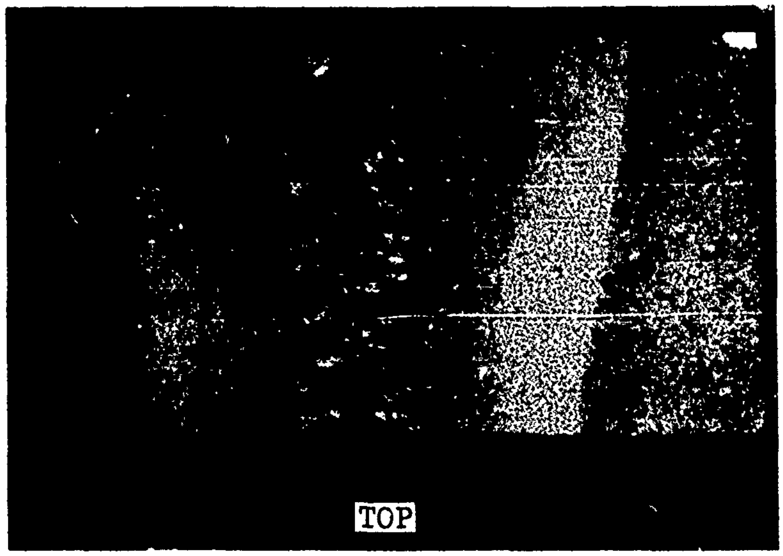
		0°F CVN
H95-1	Center of Weld	66 ft-lbs
H92-5.1	At Boundary Weld Metal	85
H92-6.1	.010" from Boundary in Weld Metal	82.5
H90-5.2	Center Fine Grain Zone (HAZ)	68.5
H90-4.2	Boundary Normal and Fine Grain Zone	63

Figure 2.1.4-28 LOCATION OF NOTCH WITH RESPECT TO EB WELD ZONES



Note the difference in the fracture appearance in the weld metal areas and the fine grain structure as the base metal is approached.

Figure 2.1.4-29 CHARPY V-NOTCH IMPACT FRACTURES AT VARIOUS LOCATIONS IN THE WELD ZONE



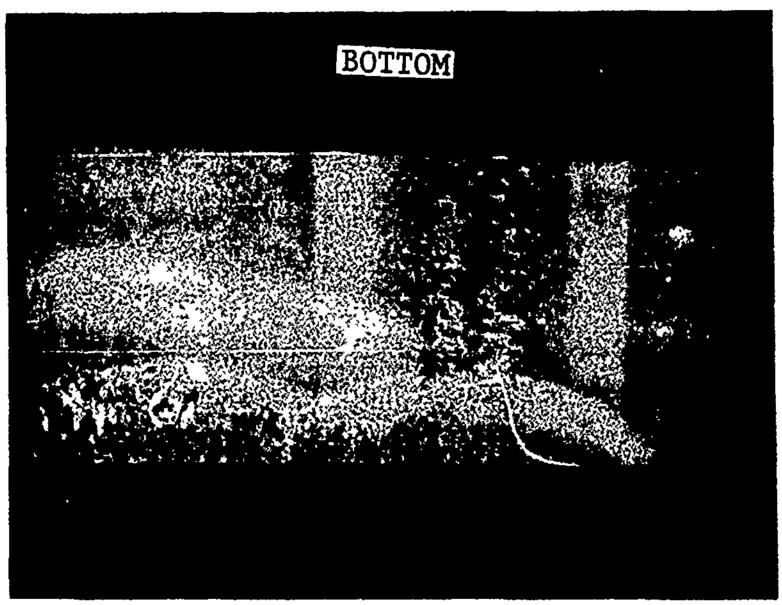
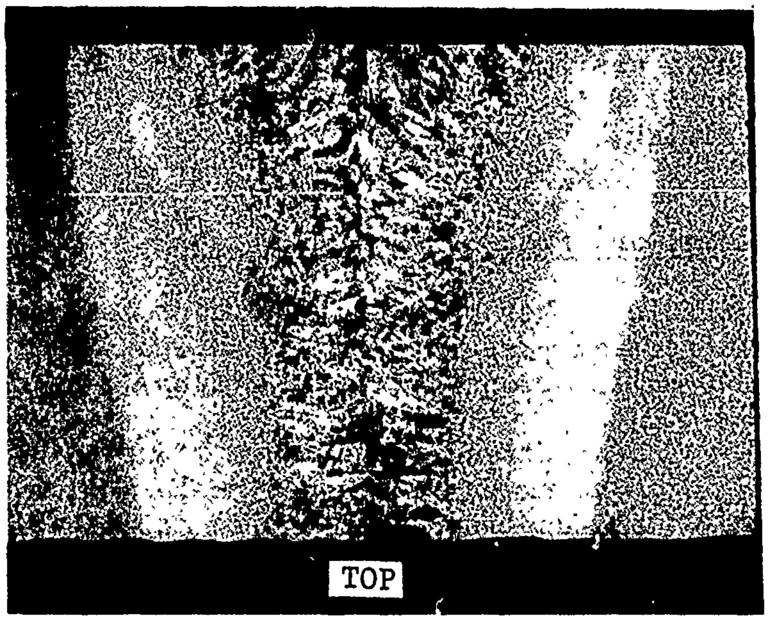


Figure 2.1.4-30 MACROGRAPHS - PANEL H89 (6X MAG)



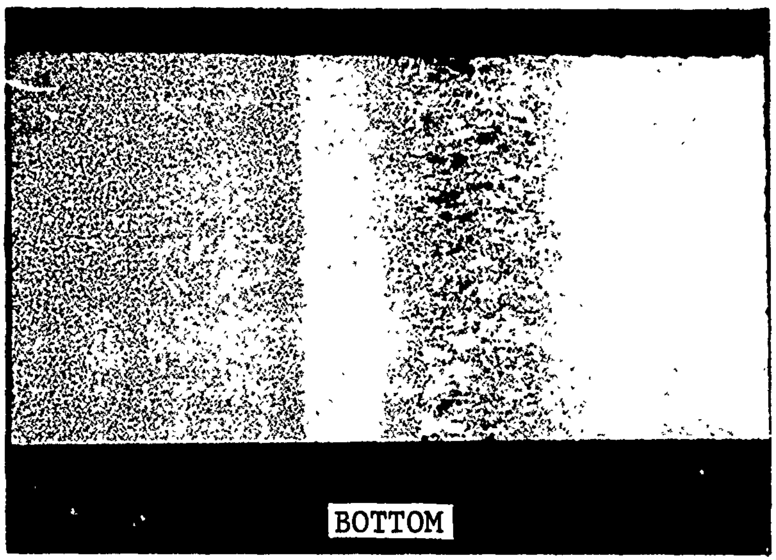


Figure 2.1.4-31 MACROGRAPHS - PANEL H91 (6X MAG)

Some concern did exist regarding the ability of the fuel tank coating to adhere to bare steel. Adherence tests were conducted and no difficulty was found to exist. The finish document FZM-6183 was revised to reflect this change and drawings now specify this finish.

2.1.4.7 Material and Process Specifications

A considerable number of material and process specifications have been required and prepared for use on the AMAVS program. A list of these specifications and their status are as follows:

X7223976	High Strength Fasteners - Stripping of cadmium or diffused nickel-cadmium platings and application of solid film lubricant and cetyl alcohol. Status - Released
X7223990	Exterior Finish. Status - Not required for AMAVS program and will not be prepared or released.
X7224194	7050 Aluminum Alloy Special Billet Procurement Specification. Status - Released but was required for FSIL configuration only.
X7224195	7050 Aluminum Alloy Billet Special Process Treatment. Status - Released but was required for FSIL configuration only.
X7224196	Sealant Application for AMAVS. Status - Three drafts prepared and final draft is in work.
X7224197	Adhesive Bonded Panel Detail Preparation. Status - Released.
X7224198	Identification of Parts. Status - Released
X7224199	Material Traceability Procedures. Status - Released
FZM-6183A	Corrosion Prevention Requirements AMAVS Program. Status - Released.
FMS-1108	Aluminum Alloy 7050 Plate, Fracture Toughness Tested. Status - Released.

FMS-1109A	Titanium Alloy, 6Al-4V, Beta Annealed Bar, Forged Billet and Plate. Status - Released with Amendment No. 1 prepared and in final sign-out.
FMS-1111	Procurement Specification for Steel Alloy, 10 Ni-2Cr-1Mo-8Co (10 Nickel) Bar, Forged Billet and Plate. Status - Released with Amendment No. 1 prepared and in final sign-out.
FMS-1112	Wire, Welding, Type 10 Nickel, Specification for. Status - Released with Amendment No. 1 prepared and in final sign-out.
FMS-1113	Proposed Procurement Specification for Titanium Alloy, 3Al-8V-6Cr-4Mo-4Zr (Beta C) Sheet and Plate. Status - Prepared and submitted to vendor (RMI Company) for review and comment. In hold pending vendor comment.
FMS-1114	Brazing Alloy, Silver-Aluminum-Manganese, Strip, Specification for. Status - Released
FMS-1115	Wire, Welding, 6Al-4V, Titanium Alloy, Extra Low Interstitial. Status - Released with Amendment No. 1 prepared and in final sign-out.
FMS-1116	Adhesive System, 270°F Cure, 180°F Service Temperature. Status - Released.
FPS-1074	Fusion Welding, Electron Beam, Specification for. Status - Released but will require minor revisions.
FPS-1092	Processing and Quality Control of Adhesive Bonded Assemblies. Status - Released along with Amendment No. 1.
FPS-1093	Aluminum-Manganese (Al-Mn) Alloy Plating, (Electrodeposited). Status - Released but has limited distribution based on licensing requirements from National Steel Corporation.
FPS-1094	Furnace Brazing of Titanium and Titanium Alloys, Specification for. Status - Released.

FPS-1095	Fusion Welding Process, General Specification for. Status - Released
FPS-1096	Heat Treatment and Process Requirements - 10 Nickel Steel. Status - Released but will require minor revisions.
FPS-1097	Inspection Processes and Acceptance Standards for Fusion Welded Assemblies. Status - Released but will require minor revisions.

2.1.5 Information Transfer

During the reporting period the final technical summary report for Phase II, Detail Design, was completed. The report, AFFDL-TR-74-17, is in publication for distribution by the AMS Program Office. The report detailed the design, analysis and testing accomplished in Phase II and presents rationale for selection of the "No-Box" Box configuration for manufacture in Phase III.

The first progress report film was completed and submitted to AFFDL. The film is 16 minutes in length and covers the Phase Ib, Preliminary Design, and Phase II, Detail Design. Considerable effort was expended to make the movie unique in featuring the integration of all disciplines during the Preliminary Design and Detail Design phases.

As a continuing effort on the part of contractors and AFFDL, ADPO, to disseminate all data obtained in the Advanced Development Programs, a complete morning session of the AIAA/ASME/SAE 15th Structures, Structural Dynamics and Materials Meeting was devoted to a panel discussion of the U.S. Air Force Advanced Metallic Structures Program. A technical paper on the Advanced Metallic Air Vehicle Structure (AMAVS) Program was presented during the panel discussion. Two additional technical papers that were written as a result of the AMAVS Program were presented later during the meeting. Two showings of the AMAVS Phase Ib and II Progress Report film were also made during the course of the meeting.

The second edition of the Material Property Data Test Report was submitted in January 1974. This report summarizes all the material property test results for Phases Ib and II. Further test data will be incorporated into the report as the material tests are conducted for the credible option test program.

The Material Test Plan and the Component Test Plan were revised to include additional credible option testing and were submitted to AFFDL for approval.

The Static, Fatigue, and Damage Tolerance Test Plan is nearing completion and will be submitted to AFFDL for approval in June 1974.

2.2 TESTING

2.2.1 Materials Testing

Materials testing as required by the initial contract was completed prior to the reporting period. Additional material testing has been negotiated and test plans are being formulated for additional testing.

2.2.2 Components Testing

Component testing as required by the initial contract was completed prior to the reporting period except for testing beyond four service lives for one of the Lower Aft Rail Centerline Splice specimens (Dwg. No. 603FTB052). Additional fatigue testing to a total of six service lives was accomplished on this specimen. A static tensile test was then performed with failure occurring at 962 kips (119% ULT) which concludes this testing. Additional component testing has been negotiated and test plans are being formulated for the additional testing.

2.2.3 Full Scale Testing

Testing is to be accomplished on a full-scale WCTS of the "No-Box" box configuration. This testing will be done at AFFDL in the test setup shown in Figures 2.2.3-1, 2.2.3-2, 2.2.3-3 and 2.2.3-4. Convair will provide test planning, test fixtures and the test article, and AFFDL will provide test equipment and perform the testing. A description of the planned testing is presented in Section 2.2.4 of this report.

The overall task of manufacturing and delivering test hardware is being performed in accordance with the plan outlined in AFFDL-TR-74-17 except that major sub-assemblies of the simulated fuselage are being built up earlier than planned and portions of the upper fixture are being assembled later than planned (during mating). This plan involves three shipments of hardware and progress for each shipment is as follows:

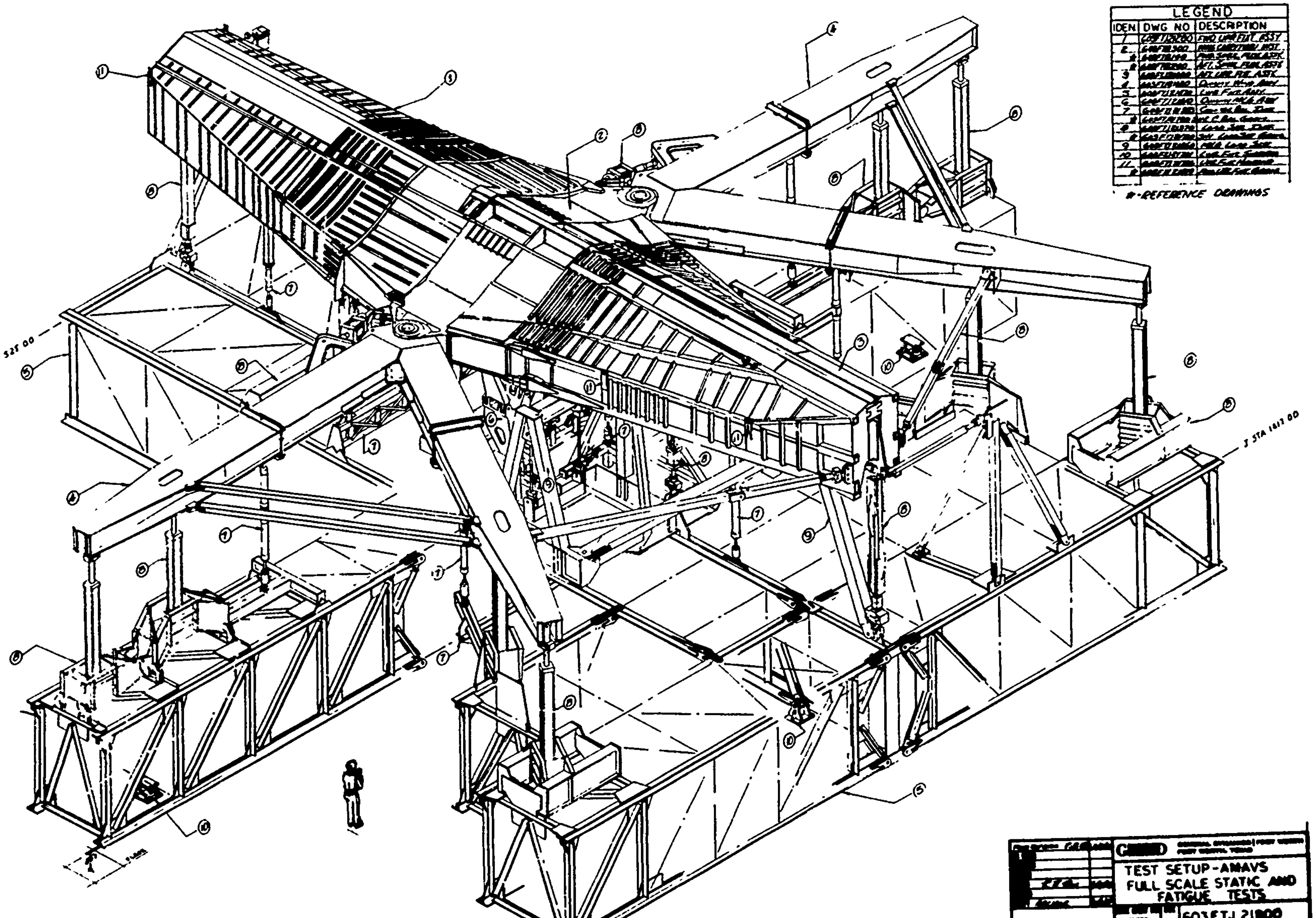

LEGEND
IDEN
DWG NO
DESCRIPTION
*-REFERENCE DRAWINGS
TEST SETUP-AMAVS
FULL SCALE STATIC AND
FATIGUE TESTS
603FTJ 21800

Figure 2.2.3-1

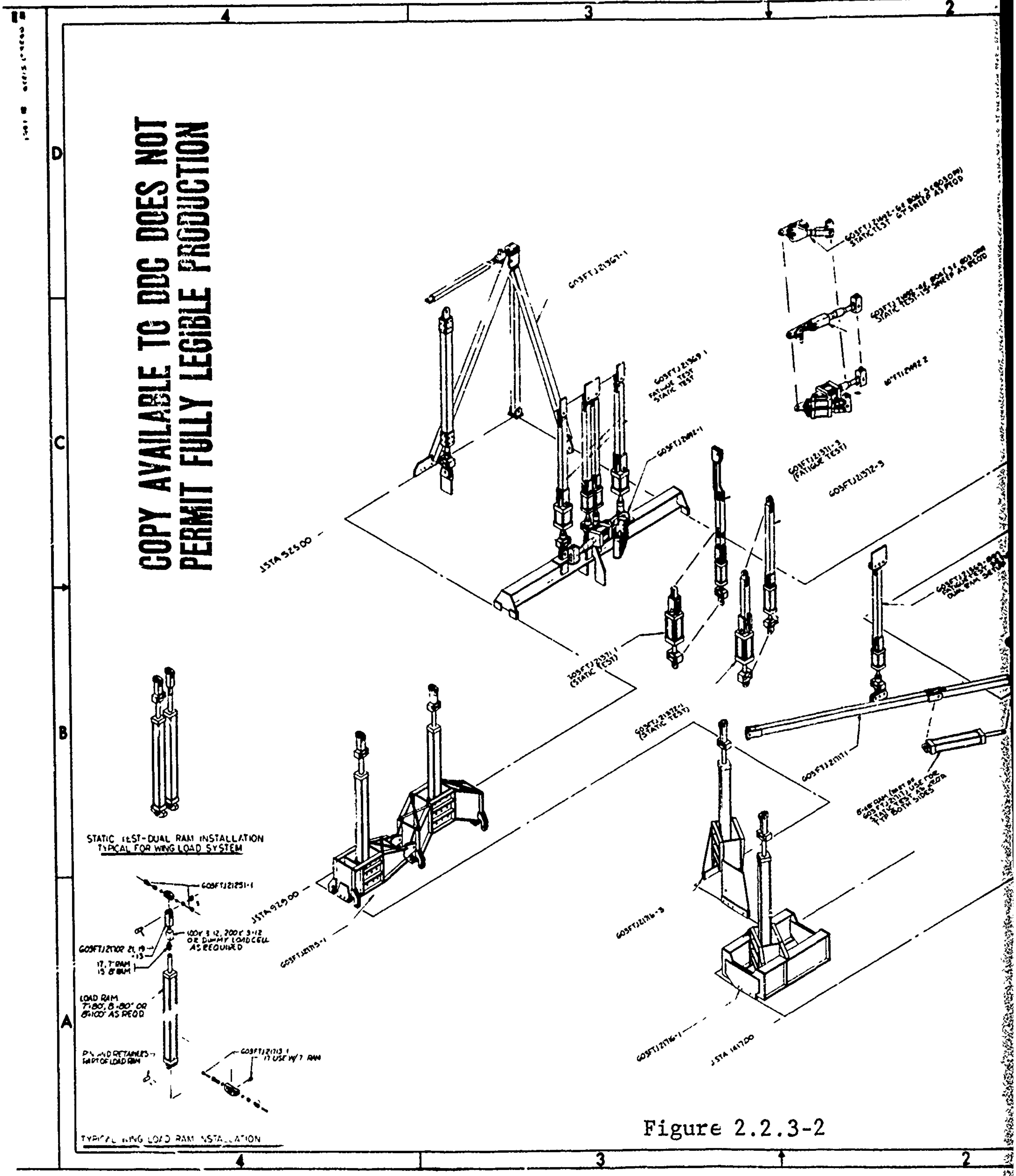

STATIC TEST-DUAL RAM INSTALLATION
TYPICAL FOR WING LOAD SYSTEM
LOAD RAM
TYPICAL WING LOAD RAM INSTALLATION

Figure 2.2.3-2

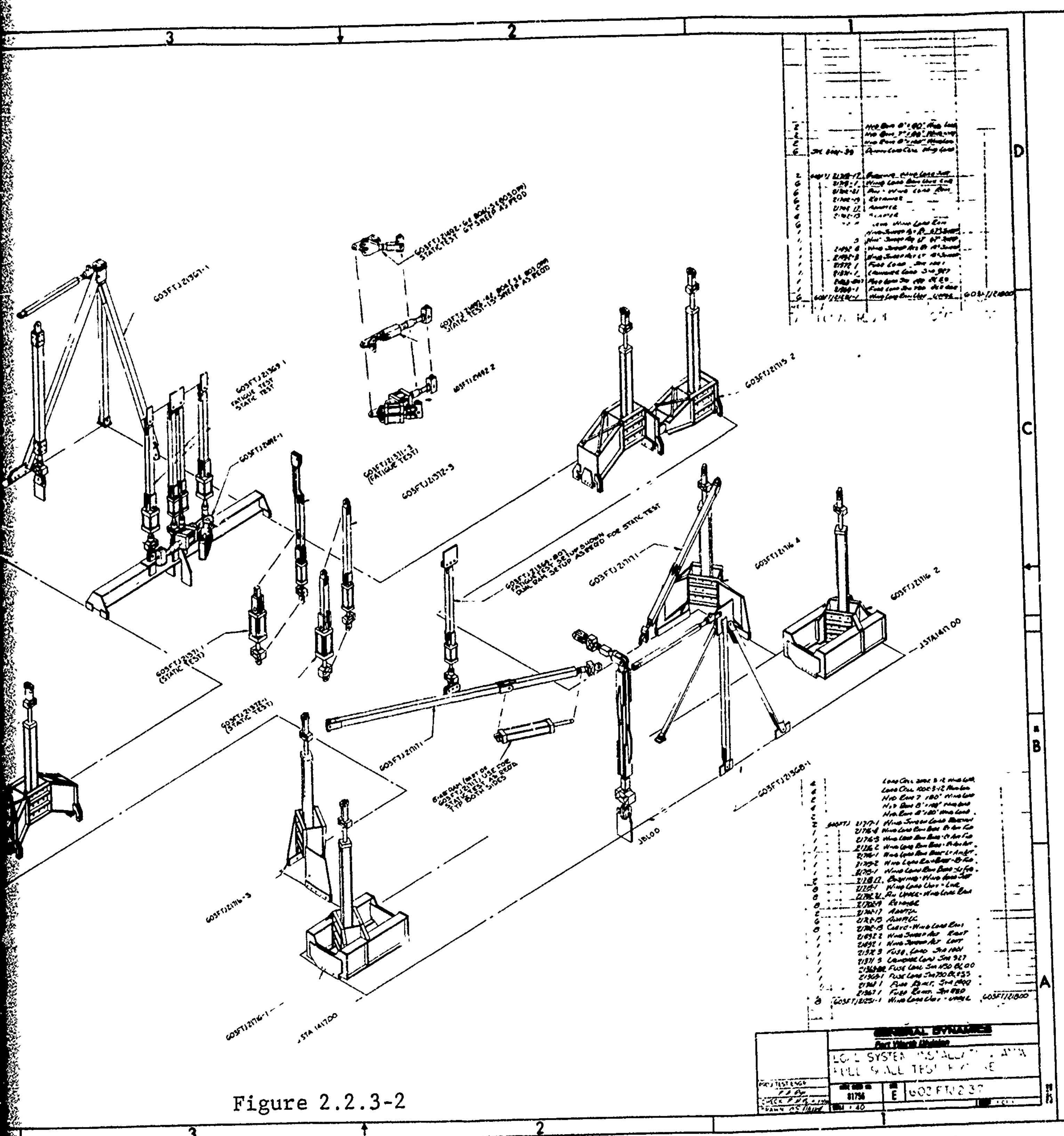


Figure 2.2.3-2

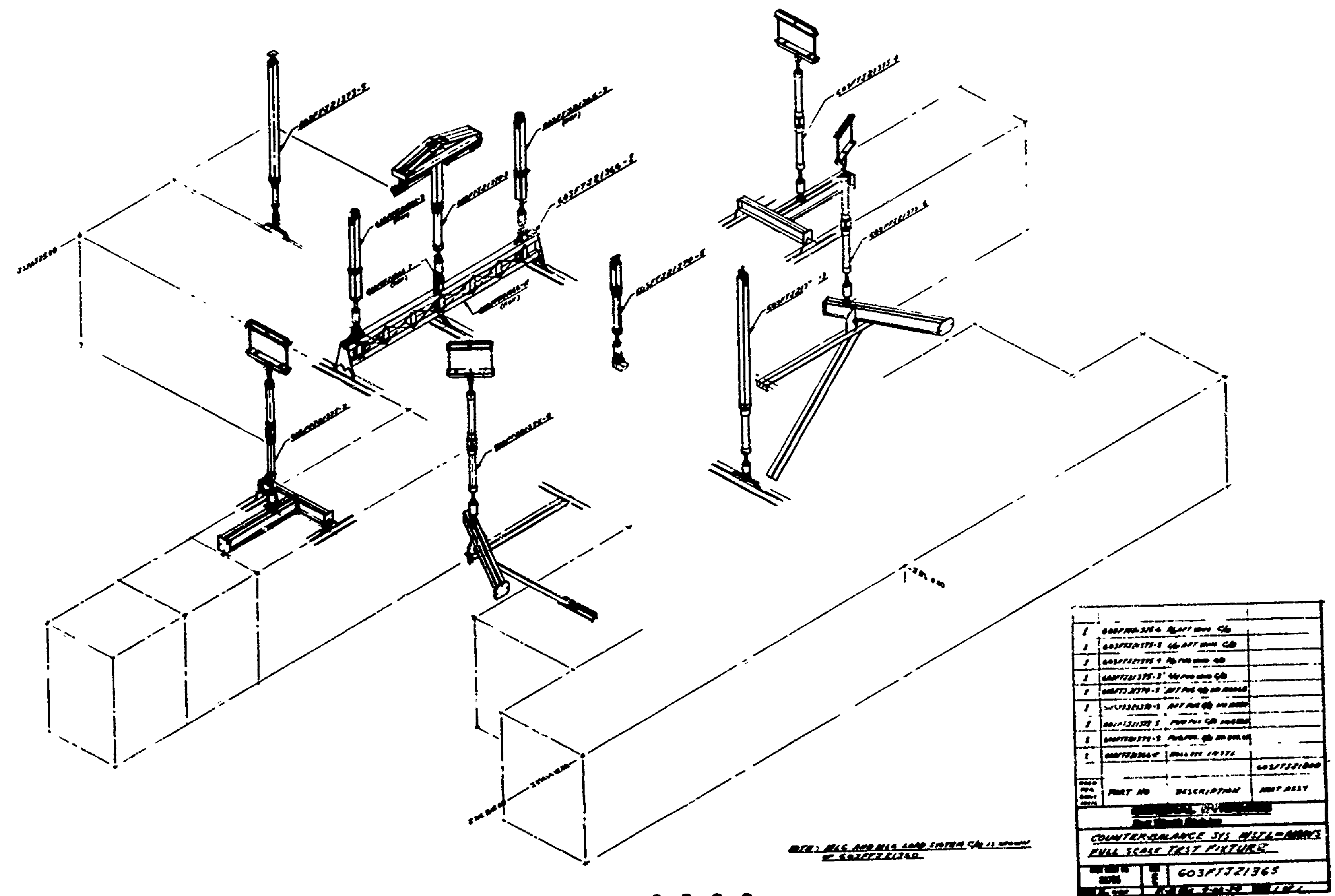
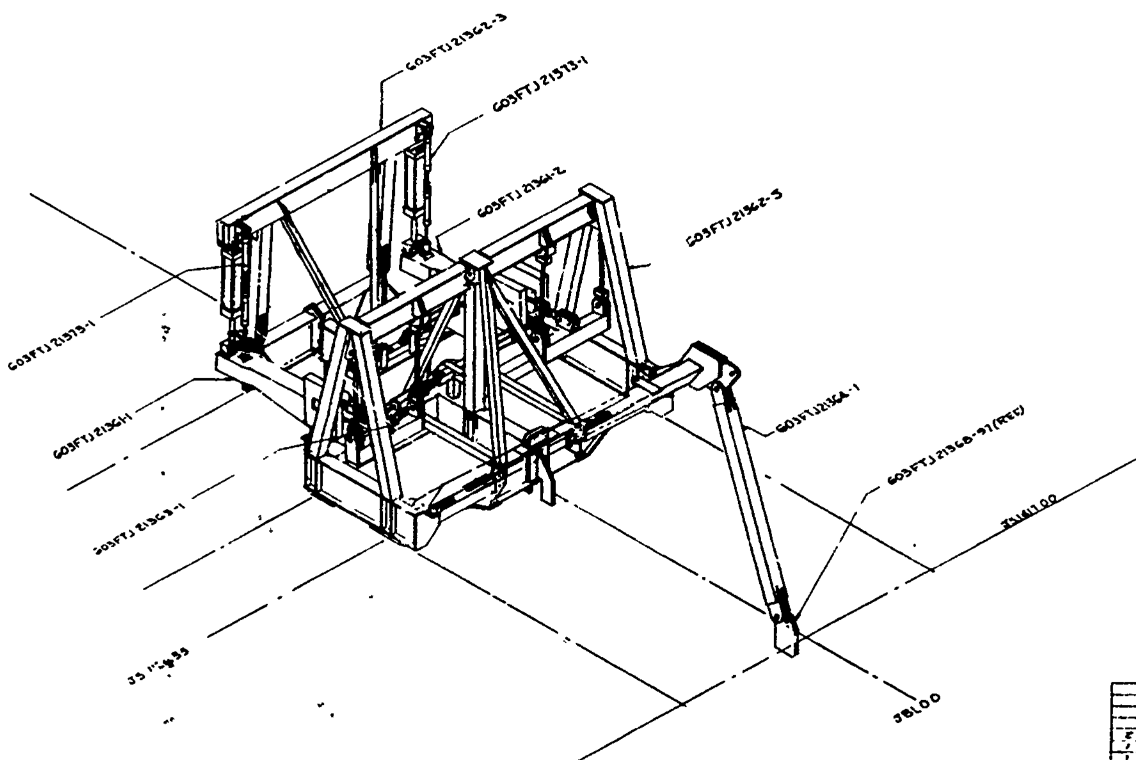
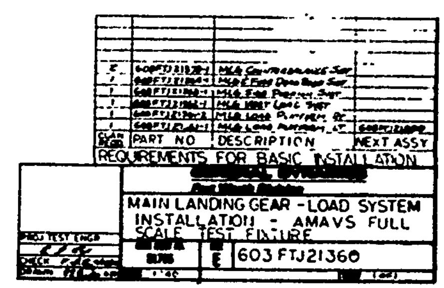

PART NO
DESCRIPTION
NEXT ASSY
G03FTJ21800
COUNTER-BALANCE SYS MSTL-ARMS
FULL SCALE TEST FIXTURE
G03FTJ21365

Figure 2.2.3-3



603FTJ21362-3
603FTJ21373-1
603FTJ21364-2
603FTJ21362-5
603FTJ21373-1
603FTJ21361-1
603FTJ21363-1
603FTJ21364-1
603FTJ21368-97(REF)
JB100



PART NO
DESCRIPTION
NEXT ASSY
REQUIREMENTS FOR BASIC INSTALLATION
MAIN LANDING GEAR - LOAD SYSTEM
INSTALLATION - AMAVS FULL
SCALE TEST FIXTURE
PROJ TEST ENGR
E
603 FTJ21360

Figure 2.2.3-4

2.2.3.1 Initial Shipment of Hardware

The test fixture base frame has been completed and most of the load systems attachment structure has been installed on the base frame. This is shown in Figure 2.2.3-5. Other load systems hardware is in manufacture. Tasks are progressing on schedule toward shipment of this hardware in early August 1974.

2.2.3.2 Second Shipment of Hardware

Manufacture of simulated fuselage sub-assemblies is described in Section 5.0 of this report. Manufacture of the upper fixture is complete except for the areas adjacent to the simulated fuselage which will be assembled during mating. Part of this structure (the forward section) is shown in mating in Figure 2.2.3-6 along with some of the mating tools.

2.2.3.3 Final Shipment of Hardware

Manufacture of the WCTS is in progress and is described in section 5.0 of this report. Manufacture of dummy hardware (wings, main landing gears, wing pivot pins and sweep actuators) is also in progress with much of the work already complete. Some of this hardware is shown in Figures 2.2.3-7 through 2.2.3-12.

2.2.4 Full Scale Test Program Test Planning

The preliminary test plan for the full scale test program has been completed. The test plan is contained in two volumes of FZS-219 dated 1 June 1974

- Volume I includes a description of the test article (WCTS), test fixture, and test set-up and includes the detail test requirements for the Fatigue Test Program, Ultimate Static Test Program, and the Damage Tolerance Test Program to be performed on the WCTS.

- Volume II includes the details of the inspection requirements for all of the test programs and the locations of the strain gages and deflection gages installed on the WCTS and fixture.

The test program defined in FZS-219 consists of testing a single complete full scale WCTS in one test fixture. The test

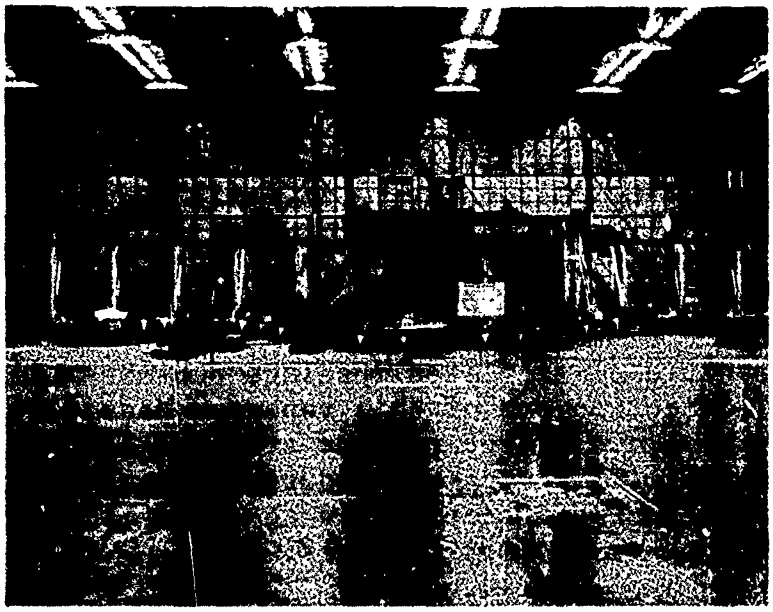


Figure 2.2.3-5 TEST FIXTURE BASE - INSTALLATION OF LOAD SYSTEMS SUPPORT STRUCTURE

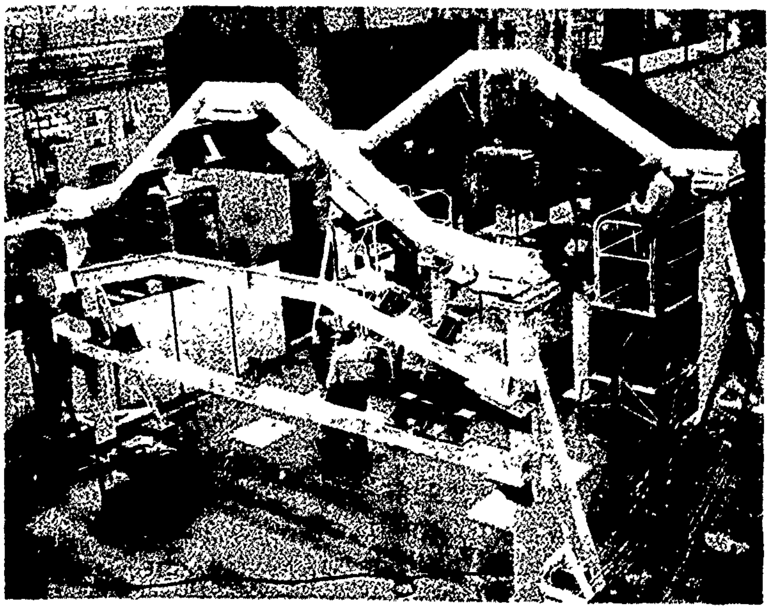


Figure 2.2.3-6 UPPER STRUCTURE ASSEMBLY AREA

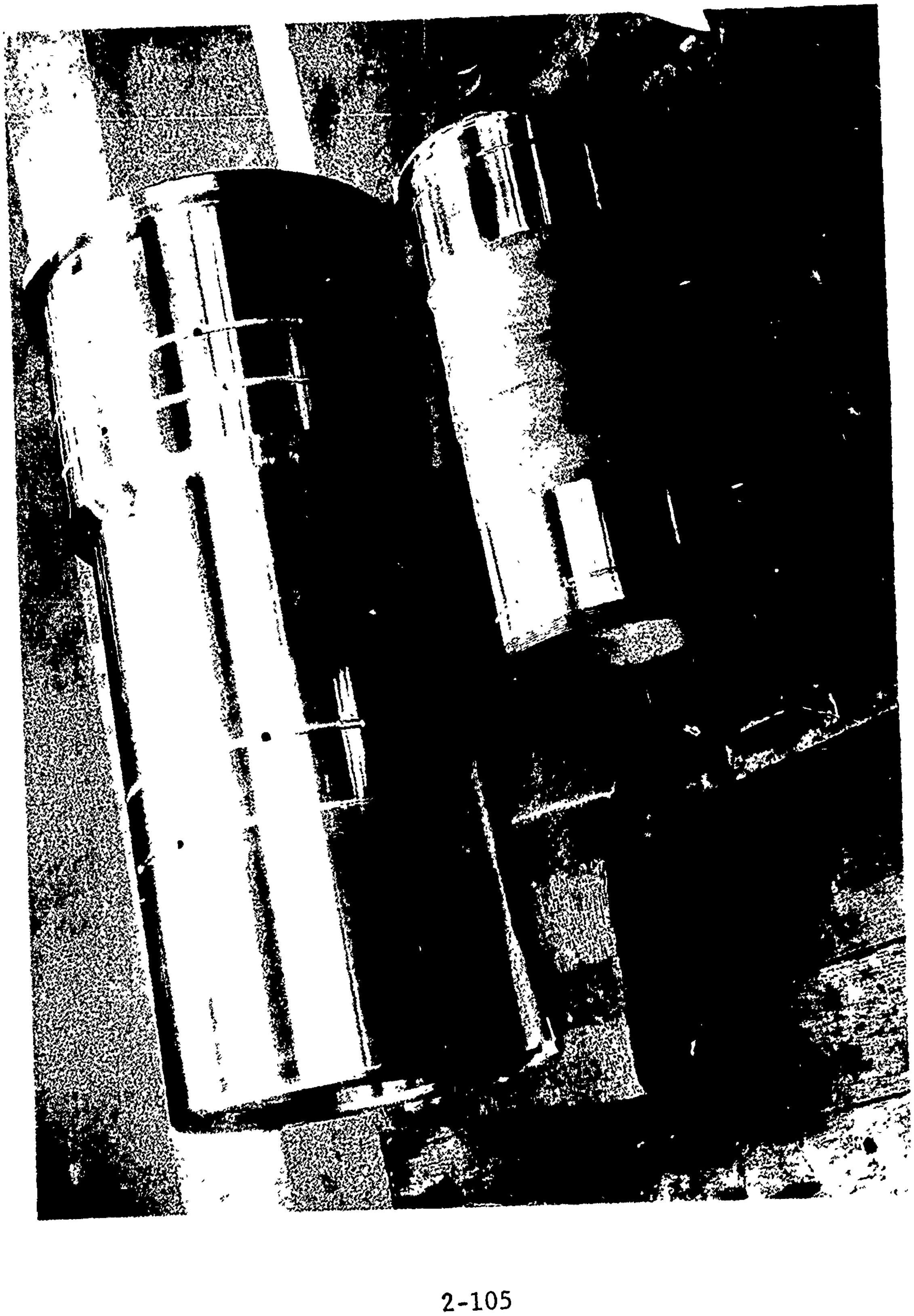


Figure 2.2.3-7 AMAVS - F-111 PIVOTS PIN COMPARISON

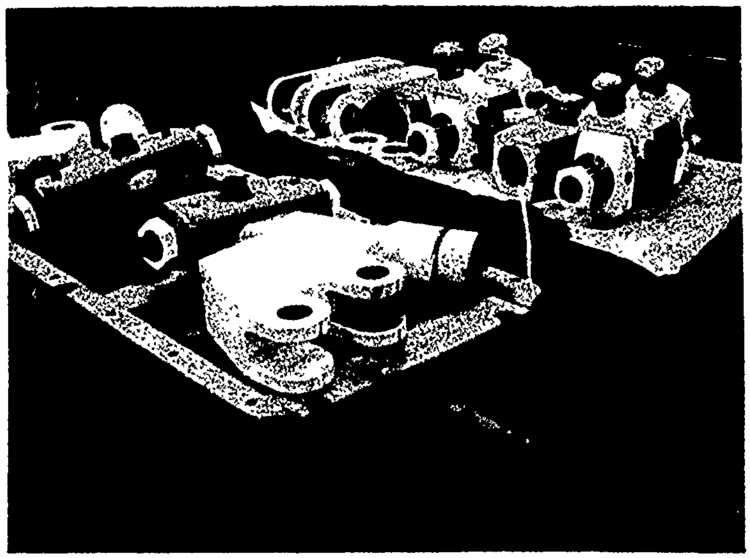


Figure 2.2.3-8 DUMMY WING SWEEP ACTUATOR - DETAILS AND SUBASSEMBLIES

Figure 2.2.3-9 DUMMY WING SWEEP ACTUATOR - SUBASSEMBLIES

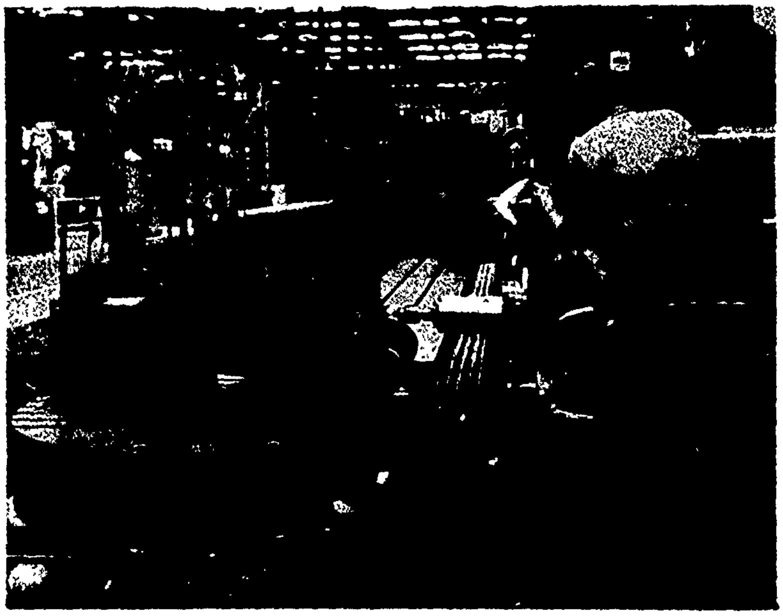


Figure 2.2.3-10 DUMMY MAIN LANDING GEAR SHOCK STRUT CASTING - SETUP FOR FINAL MACHINING

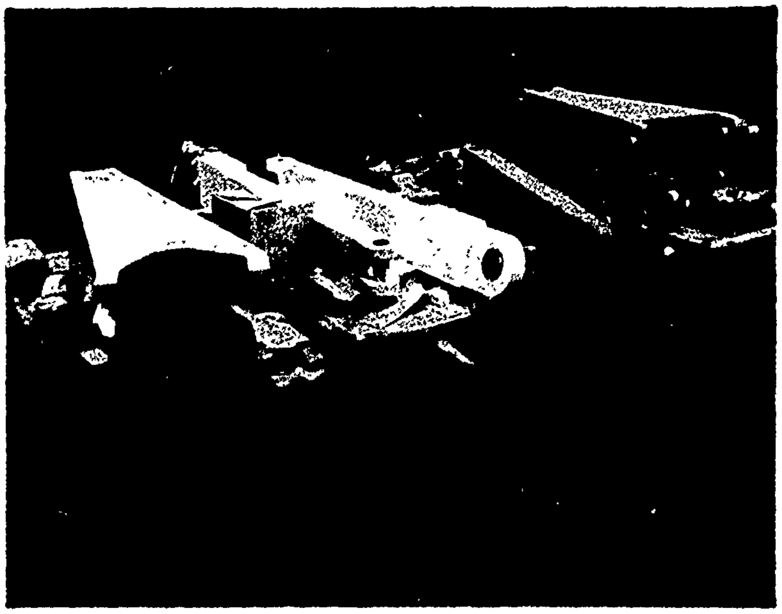


Figure 2.2.3-11 DUMMY MAIN LANDING GEAR UPPER STRUCTURE HARDWARE

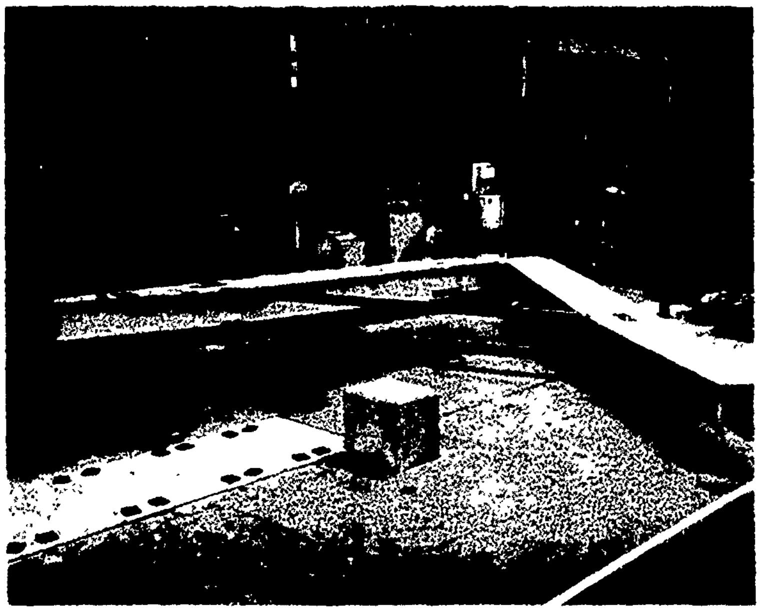


Figure 2.2.3-12 LEFT HAND DUMMY WING - FINAL ASSEMBLY

article will be installed in the test fixture and testing conducted in the following sequence:

- o Fatigue Test Program
- o Ultimate Static Test Program
- o Damage Tolerance Test Program

The following is a brief summary of each of the test programs:

- o The Fatigue Test Program consists of applying a flight-by-flight spectrum loading to the WCTS for four service lives, each life consisting of 1280 flights. Included in the initial flight loading of the fatigue testing will be a strain survey of the WCTS for each of the fatigue conditions.

- o The Ultimate Static Test Program consists of applying design ultimate load for five design conditions.

- o The Damage Tolerance Test Program consists of applying the test spectrum used in the Fatigue Test Program for one additional life after incorporation of flaws in the structure so that crack growth rates can be established for the critical areas. At the conclusion of the damage tolerance testing, one static test condition will be applied in an intentional failure test.

The sequence of testing was chosen so as to provide the greatest possibility of achieving the program objectives on a single test article.

The test programs will include extensive NDI (Non-Destructive Inspections) during the course of testing as well as strain measurements to provide close monitoring of the structure.

A schedule of the Full Scale Test Program is presented in Figure 2.2.4-1.

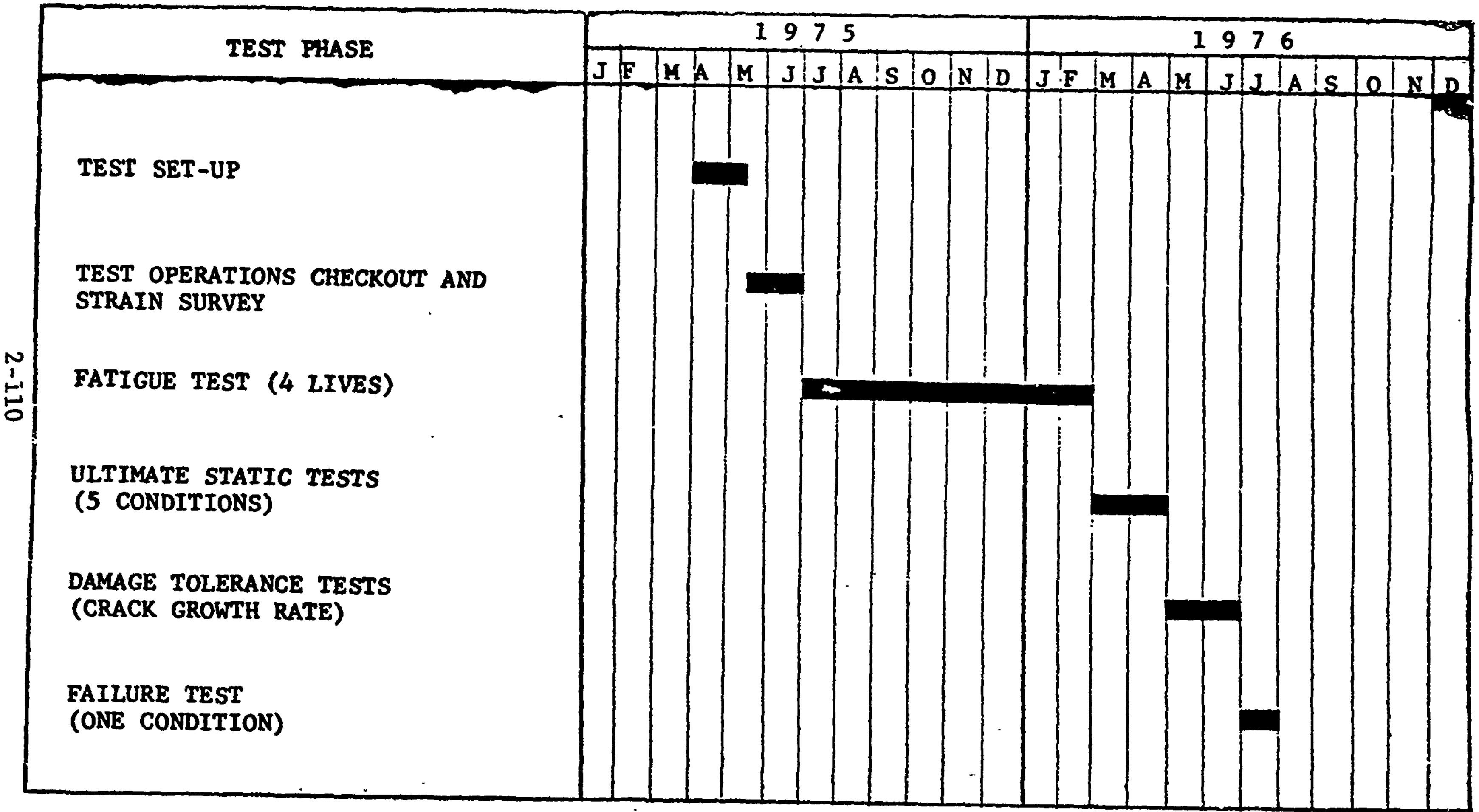


Figure 2.2.4-1 ADVANCED METALLIC AIR VEHICLE STRUCTURE FULL SCALE TEST PROGRAM SCHEDULE

SECTION 3

QUALITY ASSURANCE AND NDI PROGRESS

Quality Assurance and NDI activities are covered in this section.

3.1 QUALITY ASSURANCE ACTIVITY

The Quality Assurance effort during this reporting period was primarily concerned with updating and implementing Quality Assurance policies. These policies have established the quality controls in engineering documents and standards, process controls, acceptance tests and manufacturing planning. In addition, complete data documenting the manufacturing inspections and tests and their results are being recorded, collected and maintained. These records are providing complete traceability of product quality from raw material through the completed assembly. Special emphasis has been installed to control the fracture critical detail parts and assemblies records. A system for positive identification, analysis and correction of quality problems also has been established. Product discrepancies are recorded on Quality Assurance Rejection Reports and dispositioned for corrective action as determined by the authorized program engineering personnel.

3.2 WELD NDI DEVELOPMENT ACTIVITY

Since the provisions of FPS 1097 impose a "no cracks allowed" specification, efforts were directed toward achieving 100% inspection capability with an NDI method that provides:

- the smallest "crack" detection capability
- the optimum BSR & FSR (back surface & front surface resolution)
- a range of weld thickness inspectability that meets AMAVS requirements.

Specific problems to be resolved were primarily the traditional weld structure noise of 6Al-4V titanium (signal to noise ratios), the low or lack of response of vertical flaws, the weld structural noise of 10 Ni (not as critical as that of Ti), and the presence of responses which do not correlate with actual flaws during destructive tests.

It was established early in the program that shear and delta ultrasonic methods did not satisfy the above requirements. Delta's excellent FSR and "flaw" sensitivity was very good for parent material, but was unreliable for weld inspections. Shear wave techniques were rejected for similar reasons.

The longitudinal pulse echo approach, utilizing 10 and 15 MHz focused, immersion type transducers presented the best overall compromise for the inspection of the wide range of plate weld thicknesses in the AMAVS program. Factors making this the desirable selection are as follows:

- Full range of weld thickness inspection capability (0.250-1.8 10 Ni steel; 0.250-1.3 in. 6Al-4V Ti).
- Potential flaw detection to 0.015 inch overall diameter in a plane perpendicular to the ultrasonic beam.
- Demonstrated ability to detect vertically oriented flaws (with given limitations).
- Simultaneous flaw detection and flaw depth evaluation (± 0.100 inch for worst case measurement).
- Clear cut, well defined signals (good signal to noise ratios).
- The same technique concept applicable for both Ti and 10 Ni steel welds.
- Use of the same equipment, including transducers, for both materials (UM 721 with 10 Ni Pulser Receiver, A311 Accuscaw transducer by Panametrics or 15 SIL transducer by Automation Industries, and a bubler design permitting adjustable water depth).
- Detection evaluation independent of the non-linearity of the equipment. This is achieved through the use of comparisons of flat but reference response voltages to "flaw" amplitude response voltages in terms of voltage ratios (DBs). Regardless of gain settings or flaw depths, 50% amplitude is always 6DB; 25% is 12 DB; 12.5% is 18 DB, etc., relative to the response of the flat bottom hole selected, at the same depth as the flaw.

It was determined that shortening water travel may attenuate near surface responses and may increase back surface responses.

Increasing the water travel produces converse effects. These effects are useful, in that a certain water travel depth can be selected that presents the best compromise of usable response amplitudes for a very thick weld, while selecting perhaps another depth can enhance response at a given material depth. This is possible only if proper response amplitude curves have been plotted.

Application of the above concepts in the technique used produced satisfactory results on earlier experimental welds. Flaws were invariably located at the forecasted depths in those specimens that were made available for destructive testing. From these initial observations, a first rough assessment of the range of flaw depth was made as well as broad estimate of flaw to response amplitude correlation. Range of depth was estimated at 0.200 to 1.2 in. The correlation tests indicated between 0.015 to 0.080 inch defects for response amplitudes of 100% to 25% relative to 2/64 FBH.

Formal "flaw" size correlation tests were later made on 5 specimens. These were ultrasonically inspected and selected response were areas marked for sectioning. The data was recorded (amplitude, depth and location) and finally the specimens were sectioned. The results are shown in Table 3.2-I.

The techniques used to correlate response amplitudes to "flaw" size require extensive statistical analysis. The process consists of repeated destructive tests that show as many as possible of the flaw conditions that may occur. Only the statistical analysis of the accumulated data obtained empirically can provide confidence in a conclusion that for a given flaw response there exists an actual flaw of a given size or size range. The data available to date is insufficient to categorically determine what size of flaw exactly corresponds to 100, 50, 25 or 12.5 percent of the selected reference response amplitudes. However, based on physical properties testing of the weldments, design engineers have established a 50% ultrasonic reject level as related to a 4/64 inch diameter Flat Bottom Hole response. Further testing may require the establishment of a lower reject limit.

Aside from the limitations just mentioned with regards to the size of flaw evaluation, the NDT technique, like any other, cannot achieve 100% efficiency in flaw detection. Front surface and back surface resolution mentioned in preceeding paragraphs are certainly a limitation in "flaw" detection efficiency.

Table 3.2-I

CORRELATION TEST
AMPLITUDE - SIZE - DEPTH

SPECIMEN	ULTRASONIC DEPTH - INCHES		ACTUAL DEPTH - INCHES		FLAW WIDTH INCHES		AMPLITUDE		MATERIAL CUT		
	F. TOP	F. BOT	F TOP	F BOT	HORIZ.	VERT.	DR	% FSH	10 NI	6AL-4V	NO.
MD 3202-1	1.20	0.700	Flaw destroyed during sectioning							x	1
"	1.35	0.600	Flaw destroyed during sectioning							x	2
"	0.450	1.450	0.550	1.35	0.002	0.100	00B	100%		x	3
"	0.800	1.000	0.950	0.950	0.100	0.100	6	50%		x	4
"	0.600	1.3	0.650	1.300	0.015	0.020	0	100%		x	5
"	0.800	1.1	0.850	1.00	0.015	0.090	0	100%		x	6
"	0.600	1.4	0.700	Cont.	0.015	0.320	0	100%		x	7
H98	0.500	N/M	0.500	N/M	0.120	0.160	6	50%	x		1
H98	0.500	N/M	0.500	N/M	0.100	0.040	12	25%	x		2
H24	0.750	0.800	0.700	0.750	0.100	0.040	6	50%	x		1
H24	0.750	0.800	0.700	0.750	0.050	0.020	12	25%	x		2
H24	0.700	0.850	0.680	0.750	0.005	0.035	18	12%	x		3
H24	0.700	0.800	0.700	0.800	0.005	0.020	18	12%	x		4
H83	0.200	N/M	Flaw destroyed during sectioning				18	15%	x		1
H83	0.200	N/M	Flaw destroyed during sectioning				18	15%	x		2

N/M = Not Measured

Also, narrow vertical flaws that begin and/or end within the ultrasonically blind FSR and BSR areas produce no response This is true despite the fact that this same type of flaw is detected at all other depths.

Another limitation that needs mentioning is the requirement for a flat surface in the area of scan; any degree of tilt that increases the thickness of the water interface couplant is undesirable. In addition, surface roughness in excess of the manufacturing limits set for the parts subject to this program must be avoided.

In order to minimize the limitations, both X-ray and the ultrasonic techniques are being used to inspect the AMAVS weldments. Ultrasonics will permit detection of vertical narrow flaws that occur a good distance away from the film in X-ray tests. X-ray techniques will detect flaws that occur within the blind resolution areas of the ultrasonic techniques.

SECTION 4

MANUFACTURING ENGINEERING PROGRESS

Activity in manufacturing engineering was primarily in two areas. The R&D efforts in Phase II were extended during the period to implement developments into the fabrication of details and components for the WCTS selected for testing. The second effort organized a project group co-located with design engineering for the purpose of planning and designing tooling as required for manufacturing.

4.1 RESEARCH AND DEVELOPMENT

Developments during Phase II of this program were reported in AFFDL-TR-74-17. Those which had potential use in fabrication were designated for future expansion. The short supply of 10 nickel steel (HY 180) available during Phase II made it imperative that programs involving stock cut-off methods, drilling, machining, and welding be continued.

4.1.1 Taper-Lok Bolt Installation, 1.250 Inch Diameter

Tapered hole preparation and bolt installation for 1-1/4 inch diameter taper-lok fasteners created the need for specialized portable power equipment, cutting tools and torque equipment. An early survey revealed that cutting tools for this task required nineteen weeks' procurement time and no portable power equipment was available. Two major equipment manufacturers were conducting development of prototype units for possible AMAVS requirements.

Preliminary evaluation of tool geometry for 1-1/4 diameter tapered reamers was accomplished by modifying a core drill to selected reamer configuration. Tests were conducted on a stationary drill press to establish initial design data for procured reamers. A tool design, CJ-2218-2-20 was made for the 1-1/4 inch diameter taper reamer and three tools were ordered. These reamers are currently in stock.

MR&D engineers witnessed operational tests of "Dresser Industries", Quackenbush QDA-16 power feed drill on 21 March 1974. Tests were conducted at the Houston "Cleco" plant. A special set-up with a load dynamoter was used to demonstrate torque and thrust capabilities of the QDA-16. Torque of over 250 ft. lbs. and thrust of 300 lbs. was witnessed before indications of motor stall. Tests were repeated several times with nearly identical results. To evaluate estimated power required for reaming the 1-1/4" taper holes, a simulated set-up was made in-plant on stationary equipment, equipped with a load dynamoter. These tests showed that the QDA-16 has adequate power for the 1-1/4 inch diameter tapered reaming. The QDA-16, with the depth control attachment, was recommended for procurement. Action has been initiated to purchase the unit with estimated delivery of 30 days after receipt of order for the basic tool and 60 to 90 days for the depth control attachment. Simulated parts are complete for evaluation of the drill motor and cutting tools.

Torque requirements for installation of the 1-1/4 inch dmameter taper-lok bolt is 1200 ft. lbs. which exceeds in-plant torque tools. A Snap-On Tool Corp., X4 Geared Head Wrench, Model GA-185-3/4" to 1" - 2000 ft. lbs. capacity has been obtained for this task.

This special equipment will not be used in production until after the WCTS is completely assembled. The 1-1/4 inch taper-lok bolts are installed when the WCTS is mated with the aft simulated fuselage section prior to testing. This schedule allows sufficient time for procurement and evaluation of special equipment and related production activity.

4.1.2 Machining of 10 Nickel Steel (HY 180)

Designed tests have determined speeds, feeds and cutting tool requirements for machining 10 Nickel steel. The following recommendations for milling operations were made.

Profile and Pocket Milling (Roughing)

End Mill (Roughing): ATF-Fette, Cobalt HSS 2.0" dia. x 8 flt. 2", 4", 6" flute length

Side Milling (Cutter dia. depth max.) = $\frac{\text{1/2 Cutter dia.}}{\text{Flute length (in.)}}$

Cutter direction: Climb or conventional optional
Cutting speed: 40-50 SFM
Cutting feed: .006-.007 inches per tooth

Shell Mill (Roughing): ATF Fette Cobalt HSS 3, 4, 5" dia.

Side Milling (Cutter dia. depth max.) = $\frac{\text{Cutter dia. in.}}{6}$

Cutter direction: Climb or conventional optional
Cutting speed: 40-50 SFM
Cutting feed: .005-.007 inches per tooth

End Mill (Finishing): GD/FW 34C - Series multiflute
Cobalt per TMS Cu-25.002

Side Milling (Max. cutter dia. depth) = $\frac{\text{1/2 Cutter dia. in.}}{\text{(flute length)}^2}$

Cutter direction: Recommended conventional
Cutting speed: 50-60 SFM
Cutting feed .003-.004 ipt

Slot Milling (Pocket roughing): GD/FW 34C Series
Cobalt per TMS CU-25.002

End milling (Max. depth of end mill = $\frac{\text{Cutter dia.}}{\text{(flute length)}}^2$

Face Mill (Skin milling)

Cutter: 6NXRT-1A Lovejoy Step
6.0" dia. 7° positive axle, 4° positive radial
Insert SPG 638
Max. depth of cut: .10-.15 Max Width of cut: 90-95% of dia.
Cutter direction: Direction that clears heel of cutter
Cutter speed: 130-140 SFM
Cutter feed: .004-.005 ipt

All milling operations are to use copious flow of coolant (Gulf HD 51 or Stuart HD950) to chip cutting area.

Machinability ratings for 10 Nickel Steel have been established and are presented in comparison to better known materials in Figure 4.1.2-1.

Surveillance and technology assistance is currently being provided in specific areaa of machining when isolated milling problems arise and cutting tool changes not covered by previously issued data are required.

Data established to date is sufficient to machine the 10 Nickel components, however low metal removal rates and short cutter life emphasize the necessity of continued development of metal removal methods for cost effective production.

Machine Operation: Boring, turning, drilling and reaming		
Material	**Condition**	**Machinability Rating**
D6ac steel	*220-240 ksi	.2
Hy 180 (10 Ni steel)	200-205 ksi STA	.5
6Al-4V titanium	180-185 ksi STA	1.0
7075 aluminum	60- 75 ksi T651	9.2
Machine Operation: Band sawing, end milling, face milling		
D6ac steel	*150-155 ksi (Norm)	2.0
Hy 180 (10 Ni steel)	180-186 ksi ST	.6
6Al-4V titanium	180-185 ksi STA	1.0
7075 aluminum	60- 75 ksi T651	20.0

*Condition machining operation is normally performed.

Figure 4.1.2-1 MACHINABILITY INDEX

4.1.3 Evaluation of Machine Cut-Off Methods

Machining tests to evaluate stock cut-off methods for 10 Nickel steel and titanium plate stock to detail part sizes have revealed that band sawing, abrasive wheel sawing and planer tool parting are unsatisfactory methods.

Cutting rates for plate sawing and abrasive cutting is expressed in terms of area of material cut (sq. in.). This is in contrast to most other machining methods where material removal is measured by volume (cu. in.). The machinability factor of a given material is constant regardless of thickness. The change in cutting time due to thickness is caused by cutting media limitations. Thick sections present problems of chip removal from deep cuts. Fewer teeth in band saw blades and coarse grit radiac wheels are required which contribute to lower cutting rates. In 5 to 7 inch stock thickness machine power becomes a limiting factor.

The following information is from recent evaluations in cutting 6Al-4V titanium billets.

DoAll Pan Arm Saw (Contour capability - Manual feed)

1 Sq. In./Min. - 1" through 2-1/2" material thickness

1/2 Sq. In./Min. - 2-1/2" through 7" material thickness

1/4 Sq. In./Min. - 7" through 10" material thickness

These figures may vary slightly depending on operator technique, machine condition and other variables.

Continental Production Saw (Bar Stock Cut-Off - Power Feed)

The Continental bandsaw has a heavy blade, hydraulic feed, and a powerful motor. It can provide 40-50% cutting rate improvement over the DoAll Pan Arm saw.

Tysaman Abrasive Saw (40 HP, Mechanical feed plus oscillation and coolant)

Three pieces were cut on this machine. Rates were as follows:

.82 Sq. In./Min. - 2 inches material thickness

.87 Sq. In./Min. - 4-3/4 inches material thickness

.3 Sq. In./Min. - 7 inches material thickness

The 7" thick piece includes down time to remove broken wheels imbedded in the work and to turn the part. The test wheels were 46 grit aluminum oxide with rubber bond.

Slitting (slotting on a planer)

Two pieces 6" thick x 56" wide were cut on planers using progressively thinner slotting tools to cut half way through then turning the workpiece over to cut from the opposite side. Each piece required 16 hours including set-up time.

6" x 56" in 16 hours - .35 sq.in./min.

Limited experience in the use of a planer for material cut off makes it difficult to predict cutting rates for other thicknesses. It is not intended that this method will be pursued.

4.1.4 Development of Flame Cutting Methods for Stock Cut-Off - Titanium and 10 Nickel Steel

Inquiries to suppliers and processers of 6Al-4V titanium alloy and 10 Nickel steel revealed that flame cutting techniques were being employed for trimming of heavy plate stock in the 7-inch thick range. Insufficient data was available for utilizing the process in making detail part cut-offs. It was necessary to conduct tests to determine basic parameters and allowances.

Equipment and General Cutting Method

The equipment used was a "Mono-Trak" (Liquid Carbonic) cutting machine featuring 3-axis manual controls and a 2-axis optical tracer system. The cutting gas was oxygen and the fuel gas Mapp (Dow Chemical Company stabilized methylacetylene-propadiene) a modified form of acetylene. The preheat flame was adjusted to a slightly fuel rich condition. Straight line cuts were made by following scribed line layouts on the plates using manual controls. Non-linear cuts were made with the optical tracer system, using mylar templates.

Tests and Flame Cutting

Tests were designed to develop the process and obtain data for establishing firm procedures utilizing flame cutting as a method of producing detail part stock sized for machining. The basic needs were:

- Satisfactory cutting parameters
- Effects on material adjacent to the cuts
- Heat affected depth
- Kerf configuration
- Machining problems after flame cutting

Test pieces in selected thicknesses of both 10 Nickel and 6Al-4V titanium alloys were prepared to provide a cutting path of approximately 7.0 inches length. Observation of the test pieces during and after cutting was used to compile the parameters shown in Figure 4.1.4-1.

Specimens for macroscopic analysis were removed from the flame cut surface by electrical discharge machining. After polishing, the heat affected zone was clearly visible and measurements were taken to determine the extent of removal required to expose unaltered material. The titanium heat affected allowance was determined to be .200 inch and the 10 Nickel steel allowance was .400 inch depth. These figures were the same for all thicknesses. See Figures 4.1.4-2 and 4.1.4-3. Typical microhardness values are shown in Figures 4.1.4-4 and 4.1.4-5.

Kerf dimensions were determined by measurements from pieces that were realigned to original position after cutting. This information is included in Figure 4.1.4-6.

Flame cutting operations on steel and titanium are compared in Figures 4.1.4-7 and 4.1.4-8.

No difficulty was encountered in cutting the 6Al-4V titanium alloy in thicknesses up to 7.25 inches. Maximum thickness for 10 nickel steel was 6.4 inches thick.

Certain preparations were found to greatly aid the flame cutting of 10 Ni steel. Complete removal of mill scale from the surface nearest the cutting torch was required. This was accomplished by grit blasting or machining of the surface. Mill scale on the side opposite the torch had no apparent effect. Nearly perpendicular billet edges were required for initiation of the cutting action. This was accomplished by machining the edge or by hand grinding local areas.

STEEL ALLOY, 10 NICKEL, FMS-1111

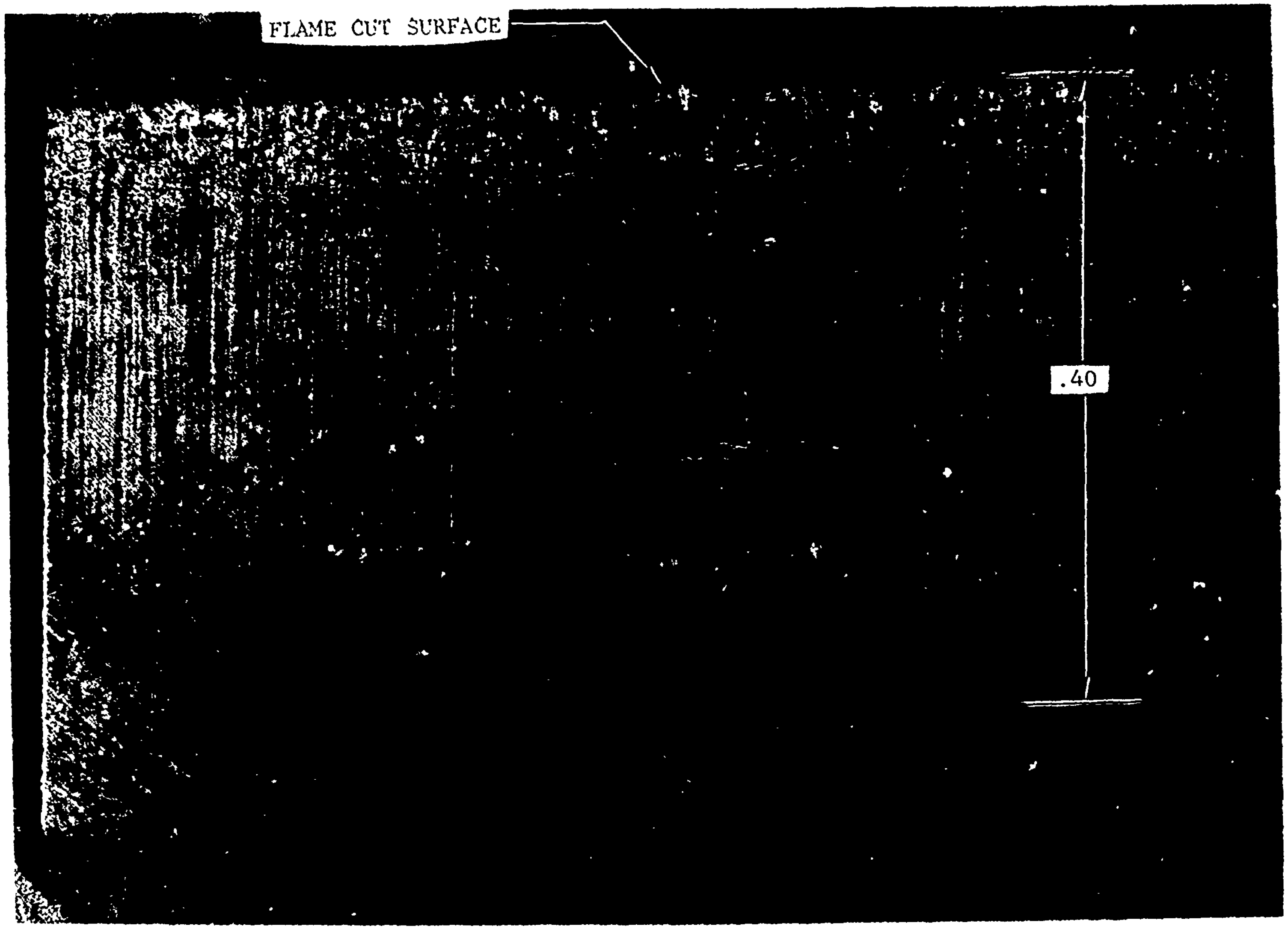
MATERIAL THICKNESS	CUTTING TIP SIZE	PRESSURE (PSI) FUEL	PRESSURE (PSI) OXYGEN	CUT. SPEED IN./MIN.	PREHEAT °F OVEN	PREHEAT °F LOCAL
5.40	31	11	90	6	300	
4.40	38	11	90	5.5	300	
3.50	44	11	90	4.5	300	
1.80	44	11	90	7-8	-	300
1.00	52	11	85	7	-	-

TITANIUM ALLOY, 6AL-4V, FMS-1109

MATERIAL THICKNESS	CUTTING TIP SIZE	PRESSURE (PSI) FUEL	PRESSURE (PSI) OXYGEN	CUT. SPEED IN./MIN.	PREHEAT °F OVEN	PREHEAT °F LOCAL
7.50	44	11	90	20	-	-
4.50	49	11	80	25	-	-
3.75	49	10	80	28	-	-
3.00	49	10	80	30	-	-
2.75	49	10	85	30-35	-	-
2.50	52	11	90	35	-	-
0.50	56	11	80	45	-	-

Figure 4.1.4-1 FLAME CUTTING PARAMETERS

Figure 4.1.4-2 PHOTOMACROGRAPH OF FLAME CUT 4.60-INCH THICK PLATE OF 6AL-4V TITANIUM ALLOY



NOTE: Arrows denote thickness of adversely affected layer - 10 Nickel Steel

Figure 4.1.4-3 PHOTOMACROGRAPH OF FLAME CUT 6.40-INCH THICK PLATE 10 NICKEL STEEL

DEPTH (IN.)	HARDNESS (RC)
.003	63
.013	52
.023	42
.033	29
.043	27
.068	28
.080	28
.108	29
.135	29
.160	27
.210	29
.260	27
CORE	27

NOTE: THIS FIGURE SHOWS FIRST 5 READINGS.

Figure 4.1.4-4 MICROHARDNESS VALUES OF FLAME CUT SPECIMENS (TITANIUM ALLOY)

DEPTH (IN.)	HARDNESS (RC)
.003	38
.005	38
.008	38
.010	40
.012	40
.015	42
.040	42
.065	42
.090	42
.115	41
.150	42
.200	40
CORE	41
CORE	42
CORE	40
CORE	41

NOTE: THIS FIGURE SHOWS FIRST 7 READINGS.

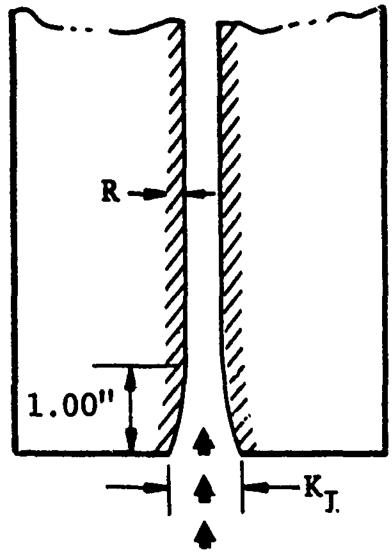
Figure 4.1.4-5 MICROHARDNESS VALUES OF FLAME CUT SPECIMENS (10 NI STEEL ALLOY)

K_I = INITIAL CUT KERF

K_T = TOP SURFACE KERF

K = INTERNAL KERF

R = HEAT AFFECTED ZONE



MATL.	"T"	K_I	K_T	K	R
10 Ni	1.00				
10 Ni	2.00		.250	.187	.400
10 Ni	3.50	.700	.350	.200	.400
10 Ni	4.50	.800	.500	.200	.400
10 Ni	5.00				
10 Ni	6.40	.900	.700	.400	.400
6-4 Ti	.50				
6-4 Ti	1.00				
6-4 Ti	2.50			.125	
6-4 Ti	3.00			.187	
6-4 Ti	4.50	.850	.550	.250	.200
6-4 Ti	5.00				
6-4 Ti	6.00				
6-4 Ti	7.50	.850	.550	.250	.200

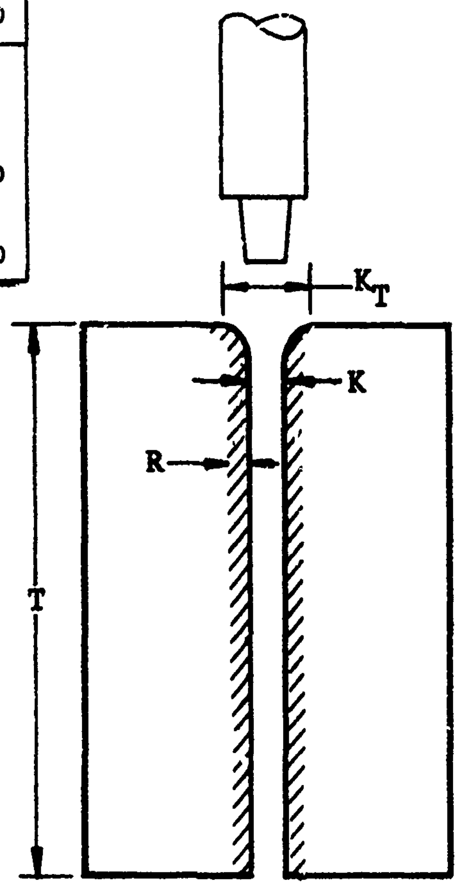


Figure 4.1.4-6 KERF DIMENSIONS

Figure 4.1.4-7 FLAME CUTTING 6.4" 10 NICKEL STEEL PLATE

Figure 4.1.4-8 FLAME CUTTING 7.25" 6AL-4V PLATE

It was found that preheating 10 Ni steel to 200-300°F made cutting easier to start and maintain. All material in excess of 2.00 inches thickness was oven heated to 300°F prior to cutting. Where this was not practical because of size limitations, the starting area was preheated with an acetylene torch.

4.1.5 Electron Beam Welding of 10 Nickel Steel

Electron beam welding procedures for 10 Ni steel were established during Phase II for .5 inch thick material; however, material above 1.0 inch thick had not been successfully welded. During this reporting period, effort was expanded to establish welding procedures for 1.6 and 1.8 thicknesses which are representative of the fore and aft bulkhead upper caps.

One of the basic problems with electron beam welding thick sections of 10 Ni steel was the occurrence of microfissures or cracks at the center of the depth of the weld. This apparently was due to the poor heat transfer and the fact that the width of the weld at the mid-point was greater than the width at the top or bottom. Another problem was the tendency of the molten column to sag creating a heavy globular underbead and severe underfill on the face of the weld.

Weld parameters that were investigated include variations of voltage, beam current, weld travel speed, beam diameter, beam oscillation, multipasses, filler wire and back up plates.

Electron beam welding procedures were established for 1.6 and 1.8 inch thick 10 Nickel steel using a single pass with an option of a wire feed cosmetic pass as shown in Figure 4.1.5-1. The root of the weld required a clean up using GTA weld repair as shown in Figure 4.1.5-2.

These procedures were used to weld seven test plates for engineering evaluation of EB welds in 1.6 inch thick 10 Nickel steel. Plate sizes are 11 x 12 and 5 x 16. One plate identified as H-89 used extensive GTA repair. This provided verification that local areas of EB welds can be repaired by GTA welding and still meet specifications. Documentation of inspection records and mechanical property data is presented in the Materials Engineering Section 2.1.4. The welding of these test plates and mechanical property data obtained verified the welding schedules and assisted in certification of the operator and welding equipment.

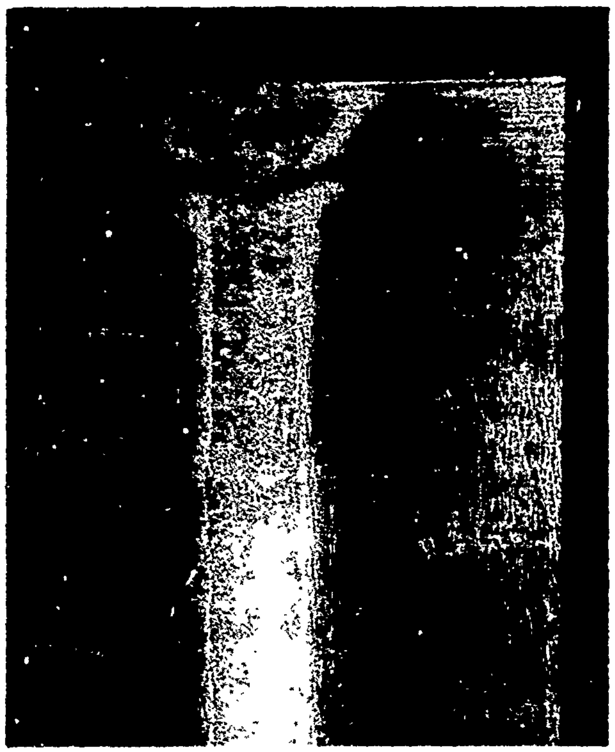


Figure 4.1.5-1 TOP SURFACE - EB WELDED SPECIMEN - 10 NICKEL STEEL

Figure 4.1.5-2 BOTTOM SURFACE - EB WELDED SPECIMEN WITH GTA WELD REPAIR ADDED - SPECIMEN - 10 NICKEL STEEL

Representative Test sections of the upper rail joint as shown in Figure 4.1.5-3, have been welded to verify the welding procedures for Tee sections and to prove the production tooling. Sections welded were 1.8 and 1.6 inch thick. Welding of these items established the weld schedules and certification for the production parts. Weld schedules are shown in Figures 4.1.5-4 and 4.1.5-5. Parts submitted to X-Ray and ultrasonic inspection were of Class I quantity. The inspection records are shown in the Materials Engineering Section 2.1.4.

A standard of 1 gauss maximum was established for demagnetizing of parts to be electron beam welded. This requirement did not present any problems during development welding on small pieces of material. However, the larger size production parts presented problems. The gauss readings do not remain stable and tend to increase during transportation and weld set up.

Vacuum Chamber Extensions

Due to the excess length of the four bulkhead cap assemblies, X7224071-9 and X7224091-9, chamber extensions were required. Chamber extensions were designed and installed as shown in Figure 4.1.5-6.

The existing chamber was 74 inches long. The overall length of the caps is 103 inches. The extensions shown in Figure 4.1.5-6 are 18 inches in diameter and 40 inches long. The existing windows were removed and bolted to the outboard end of the extensions. It should be noted that the extensions are supported by die wagons equipped with cradles that have four adjusting bolts for levelling and to distribute the pressure on the door seals. The total volume of the chamber was increased from 53 cu. ft. to 65 cu. ft. by adding the two extensions. It was originally anticipated that the pump down time would be increased but actual experience has shown that with an average load the pump down to welding vacuum of 3 x 10^{-5} mm/hg. is 10 minutes. Leak rate is minimal since the chamber has been pumped down on Friday and still had vacuum on Monday.

4.1.6 GTA Welding Development of 10 Nickel Steel

Weld groove configuration for .65 inch thick material was established during R&D investigations. The configuration was used on test plates made for certification of welding procedures. The same groove was machined on webs and caps of the forward and aft bulkhead weld joints.

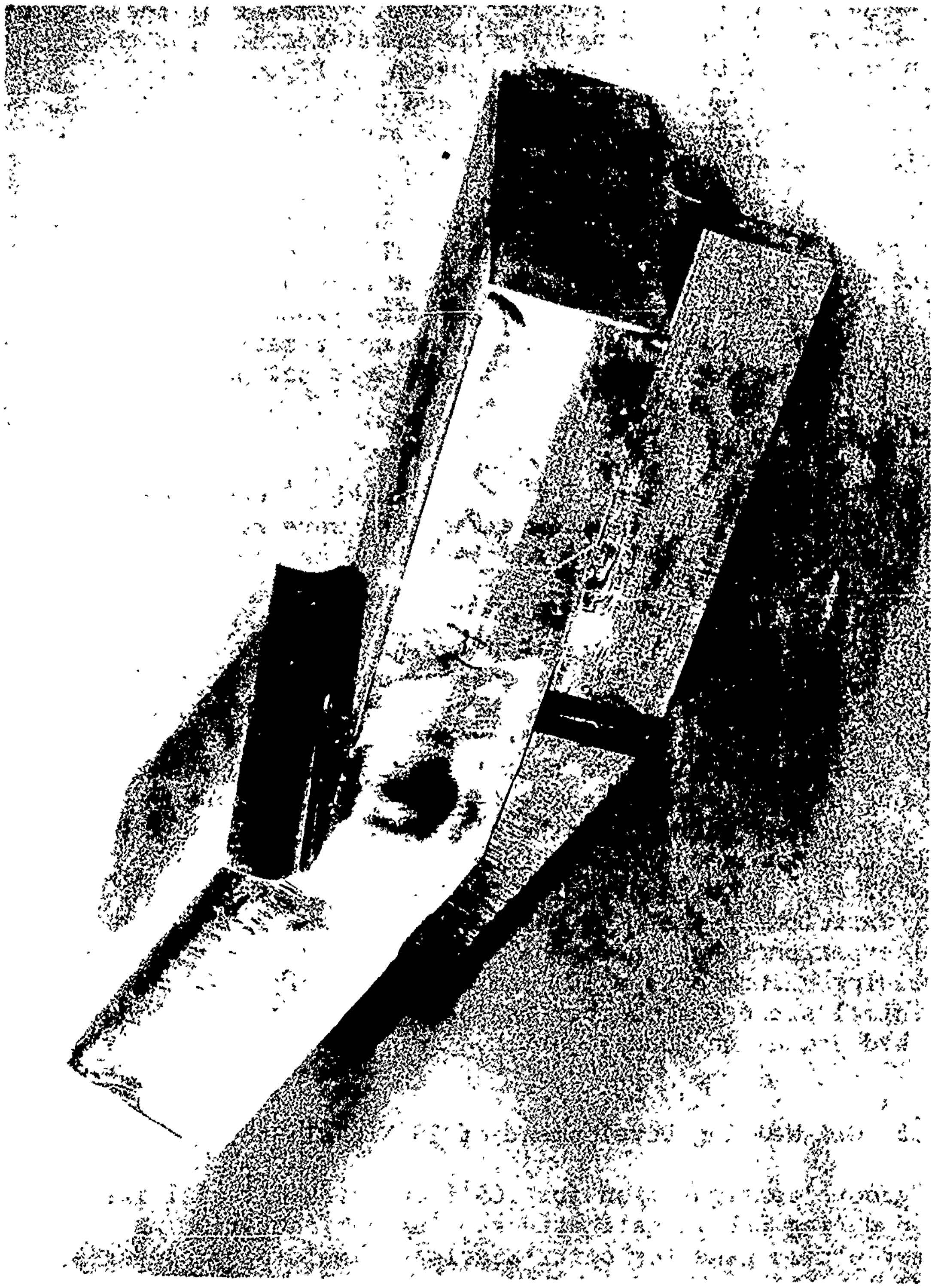


Figure 4.1.5-3 TEST SECTION - UPPER RAIL TEE JOINT

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS No. 2 Date 5-3-74
Part Number X722071-9 Part Name GAP WELD SUBASSY. Material Type 10 NI (HY180)
Serial Number 402629 Tool Number T17315 Mat'l. Thick 1.83
YF 992 Bulkhead Filler Wire Type Low Alloy (HY180) Diameter .062
10 Ni CR-MO-CO
Ht. No. 51361

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5.2	2 6 0	
Seconds: 0 15 30 60 120	Seconds: 0 15 30 60 120	Slope: 2 0 2	Slope: 0 1 7	Run:

OSCILLATOR

AXIS X ☐ Y ☐ FREQUENCY, KC ☐ RANGE ☐
ATTENUATION, Db ☐ METER RANGE ☐ METER READING ☐

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	4 0 0	4 7 .0	1 2 0
Pass 2	1 4 0	2 2 .0	1 2 0
Pass 3			

FOCUS CURRENT METER 5 .2 2 DC Amps.
GUN FILAMENT METER 0 6 8 AC Amps.
FILAMENT ADJUST POT. 0 7 6

SKETCH OF JOINT

TYPE OF JOINT

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	6 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On ☐ Off ☐
METER, AC VOLTS ☐
VOLTAGE ADJUST. ☐
GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS	On ☐ Off ☐	Y-AXIS	On X Off ☐
DIRECTION	Fwd. ☐ Rev. ☐	DIRECTION	Fwd. ☐ Rev. X
TRAVEL SPEED, IPM		TRAVEL SPEED, IPM	1 2 .0
WIRE FEED	On X Off ☐	INCH PER MINUTE	2 5 .0
BEAM ALIGNMENT		FOCUS ADJUST.	5 .2 2
HIGH VOLTAGE ADJUST.	NOTED	AVR	Lock ☐ Unlock X

X-Ray Serial Number ______
Mag. Inspection ______ Operator N. E. Wedel
Acceptance Standard ______ MR&D Engineer J. C. Collins
Metallurgical Exam. ______ Process Control ______

Figure 4.1.5-4 ELECTRON BEAM WELDING SCHEDULE - X722071-9

ELECTRON BEAM WELDING SCHEDULE

Schedule Number AMAVS No. 1 — Date 5-3-74

Part Number X7224091-9 — Part Name CAP WELD SUBASSY. — Material Type 10 NI (HY180)

Serial Number F402625 — Tool Number T17315 — Mat'l. Thick 1.60

YF932 Bulkhead — Filler Wire Type Low Alloy HY180 — Diameter .062

10 Ni CR-MO-CO

Ht. No. 51361

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 0	N/A
Seconds	Seconds	Slope	Slope	Run
0 15 30 60 120	0 15 30 60 120	2 0 2	0 1 7	

OSCILLATOR

AXIS X [ ] Y [ ] — FREQUENCY, KC [ ] — RANGE [ ]

ATTENUATION, Db [ ] — METER RANGE [ ] — METER READING [ ]

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 8 0	4 6 .0	1 2 .0
Pass 2	1 4 0	2 2 0	1 2 .0
Pass 3			

FOCUS CURRENT METER 1- 5 .2 2 DC Amps. 2- 5 .9 5

GUN FILAMENT METER 0 6 8 AC Amps.

FILAMENT ADJUST POT. 0 7 6

SKETCH OF JOINT

TYPE OF JOINT Tee butt with backup bar

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On [ ] Off [ ]

METER, AC VOLTS [ ]

VOLTAGE ADJUST. [ ]

Face Focus

GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS	On [ ] Off [ ]	Y-AXIS	On [X] Off [ ]
DIRECTION	Fwd. [ ] Rev. [ ]	DIRECTION	Fwd. [ ] Rev. [X]
TRAVEL SPEED, IPM		TRAVEL SPEED, IPM	1 2 .0
WIRE FEED	On [X] Off [ ]	INCH PER MINUTE	2 5 .0
BEAM ALIGNMENT		FOCUS ADJUST.	2 .2 2
HIGH VOLTAGE ADJUST.	NOTED	AVR	Lock [ ] Unlock [X]

X-Ray Serial Number

Mag. Inspection

Acceptance Standard

Metallurgical Exam.

Operator N. E. Wedel

MR&D Engineer J. C. Collins

Process Control

Figure 4.1.5-5 ELECTRON BEAM WELDING SCHEDULE - X7224091-9

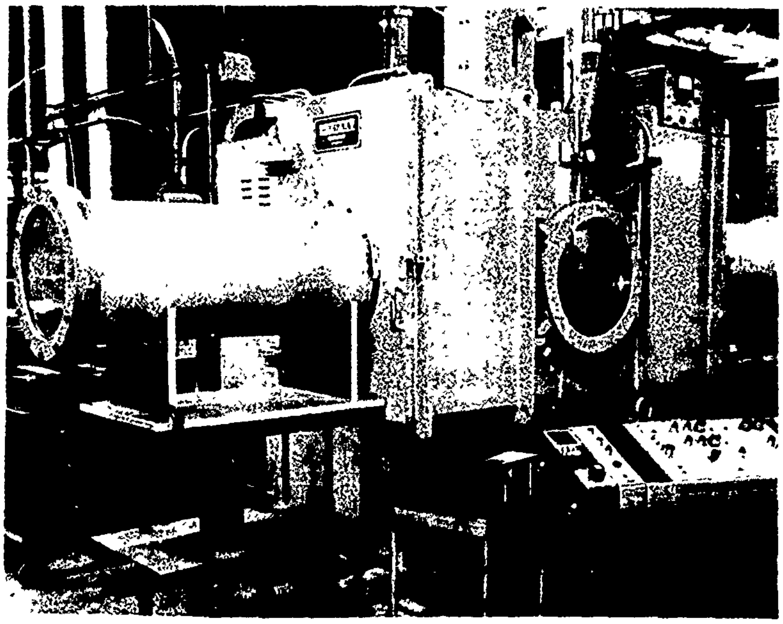


Figure 4.1.5-6 EB WELD CHAMBER EXTENSIONS

Welding from both sides of the parts was evaluated as a method of controlling weld shrinkage. This approach required excess handling and set up time and the decision was to make all welds from one side of a bulkhead. The machined groove for the .65 inch material is shown in Figure 4.1.6-1.

Weld warpage tests were made. A .65 inch thick test specimen was welded to determine the exact amount of warpage and prebow necessary to offset the warpage in a welded assembly. The specimen was welded using the production shape groove and welder certification settings. The resultant warpage was measured and calculated to be 49 minutes. A prebow of 49 minutes was then incorporated into the production tool as illustrated in Figure 4.1.6-2. This tool was used for welding both the upper and lower caps to the bulkhead webs.

GTA welding of the 1.8 inch thick upper cap splice joint was investigated using a modification of the weld groove developed for the .65 inch thick material. The included angle was changed from the 40° shown in Figure 4.1.6-1 to a 20° included angle. The 20° angle was used to reduce the number of weld passes required and also to minimize the weld warpage in the 1.8 inch thick joint. The welding schedule established for the .650 inch thick material was used for the 1.8 inch material. A total of 72 passes were required to fill the weld groove.

Excess weld bead was removed by machining. The X-Ray indicated excellent weld quality.

The 1.8 inch thick test specimen was set up with a .090 inch spacer under the center of the test specimen. This was to prebow the specimen to offset weld warpage. After welding, approximately .030 inch prebow remained in the part.

4.2 MANUFACTURING ENGINEERING - TOOL PLANNING DESIGN AND FABRICATION

Manufacturing engineers assigned to design coordination during Phase II obtained fabrication cost estimates on all designs for cost-to-weight trade-off studies made during the design phases. Cost of these components influenced the selection of the "No-Box" Box configuration for fabrication. From these Phase II studies the manufacturing planning, tool requirements, and fabrication processes were established for the manufacture of a single WCTS test article in the current Phase III period.

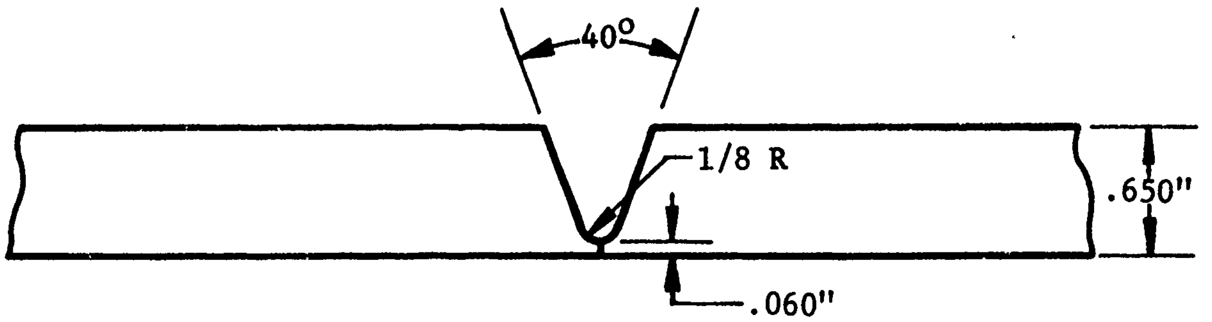


Figure 4.1.6-1 WELD JOINT DESIGN FOR GTA WELDING OF 10 NICKEL STEEL

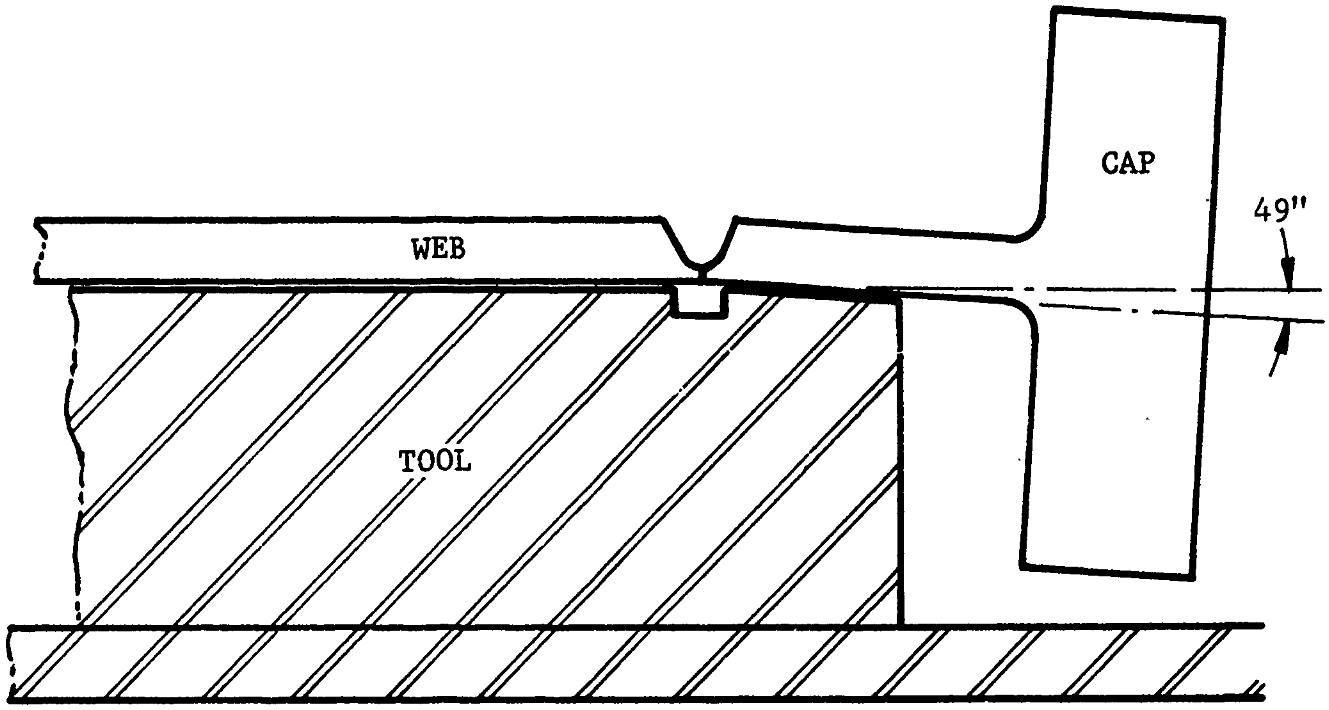


Figure 4.1.6-2 TOOLING PREBOW FOR GTA WELDING

4.2.1 Manufacturing Engineering Policy

The basic tooling and manufacturing policy was formulated to accomplish the detail fabrication and assembly of the end article economically and efficiently with particular emphasis on quality. Detail part fabrication tools and methods were chosen on the basis of complexity and economy. Standard mill vices, angle plates, rotary tables, etc. were utilized where possible to eliminate special tools. Template type duplication patterns made from existing numerical control master design layouts (MSLO) were used on conventional machine routers and profilers. Numerical control tapes were prepared for high cost and complex machined parts of 10 Nickel steel and titanium.

Subassembly tools were limited to use only where they removed a significant amount of work from the final assembly fixture or provided the most economical method of assembly.

Details for adhesive bonded assembly tools were made for left hand assemblies only where left and right hand parts were mirror images. Tool and bonded assembly fabrication was scheduled to allow time for disassembly of the left hand tool details and reassembly of details on the same base to provide for right hand assembly bonding. Elimination of the right hand base and details followed the minimum tool concept for the program.

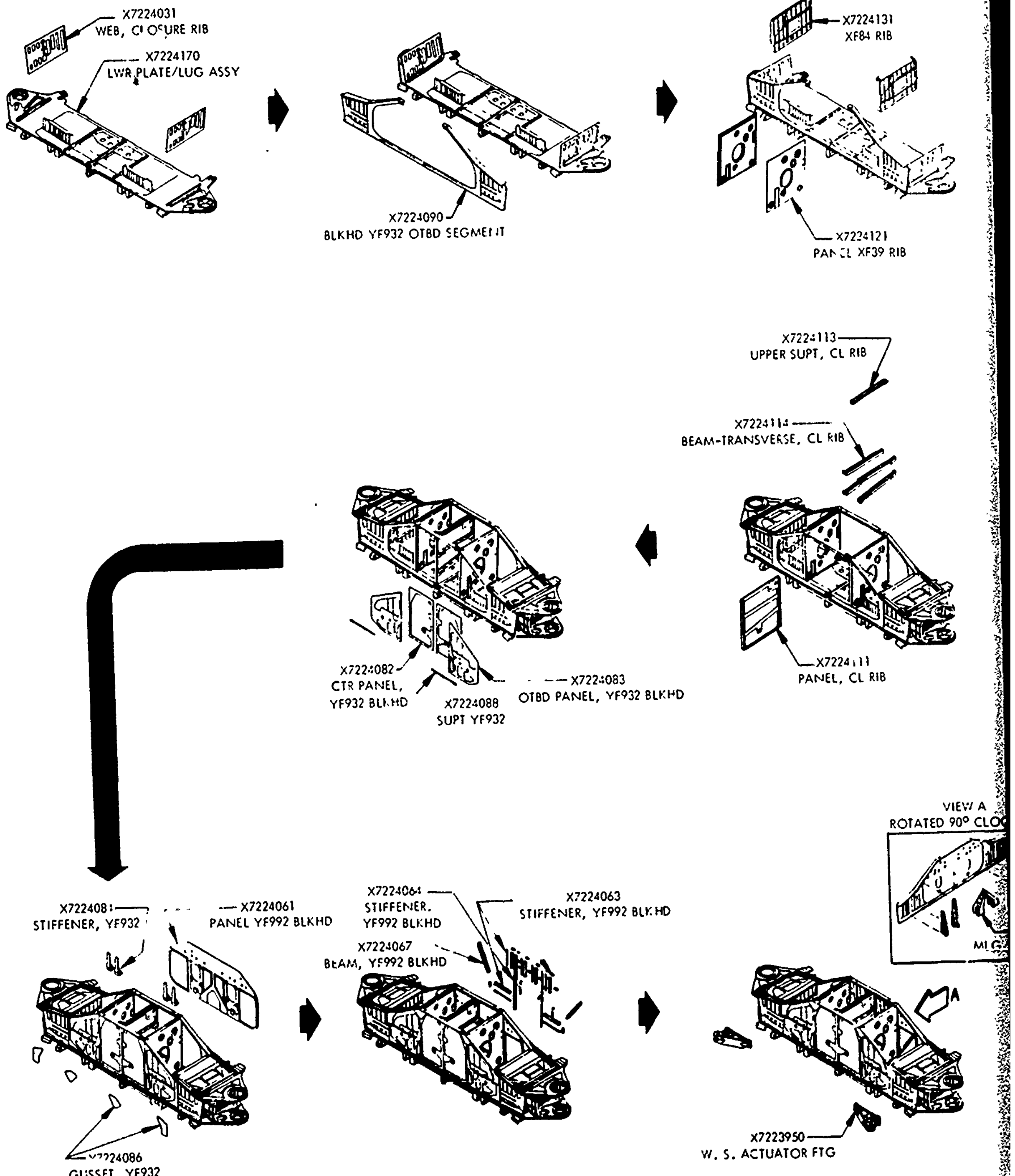
4.2.2 Manufacturing Plan for WCTS

The assembly sequence of the major components which comprise the WCTS is presented in Figure 4.2.2-1. For scheduling purposes the planning stations 1 through 5 have been established as shown in Figures 4.2.2-2 through 4.2.2-6.

Tool planning, design, and manufacturing including N/C tape programing and try-out proofing was scheduled to follow fabrication schedules shown by planning stations in Figures 4.2.2-7 through 4.2.2-11.

4.2.3 Manufacturing Cost Estimates

Cost estimates for material, detail part fabrication, assembly of details, and all related manufacturing engineering and tooling functions were prepared in Phase II as previously stated. These estimates were made by detail part numbers from preliminary manufacturing analysis (PMA) forms for the cost of manufacturing one WCTS only.



X7224031
WEB, CLOSURE RIB
X7224170
LWR PLATE/LUG ASSY
X7224090
BLKHD YF932 OTBD SEGMENT
X7224131
XF84 RIB
X7224121
PANEL XF39 RIB
X7224113
UPPER SUPT, CL RIB
X7224114
BEAM-TRANSVERSE, CL RIB
X7224111
PANEL, CL RIB
X7224082
CTR PANEL,
YF932 BLKHD
X7224088
SUPT YF932
X7224083
OTBD PANEL, YF932 BLKHD
X7224081
STIFFENER, YF932
X7224061
PANEL YF992 BLKHD
X7224086
GUSSET, YF932
X7224064
STIFFENER,
YF992 BLKHD
X7224067
BEAM, YF992 BLKHD
X7224063
STIFFENER, YF992 BLKHD
VIEW A
ROTATED 90° CLO
A
X7223950
W. S. ACTUATOR FTG

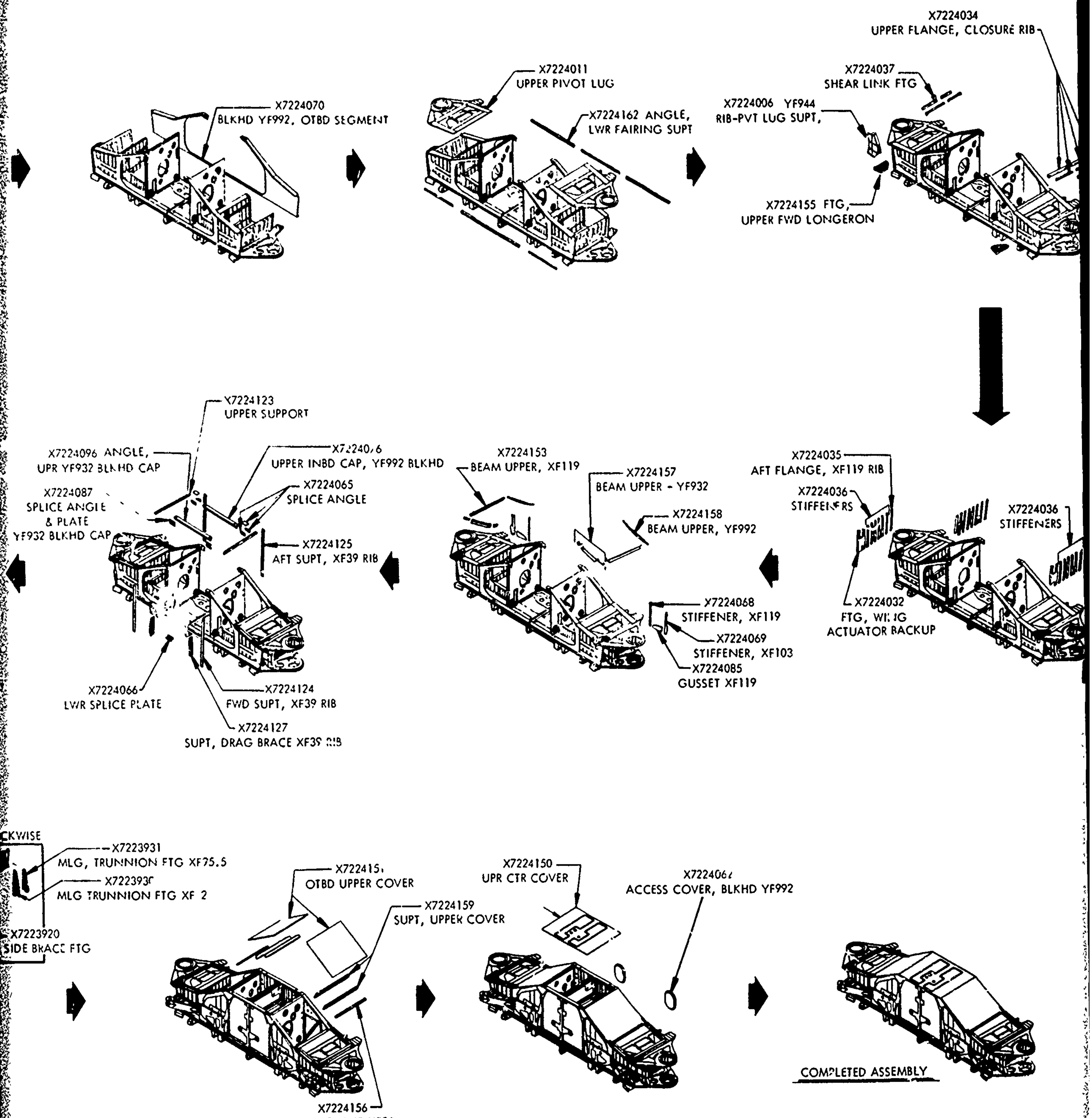
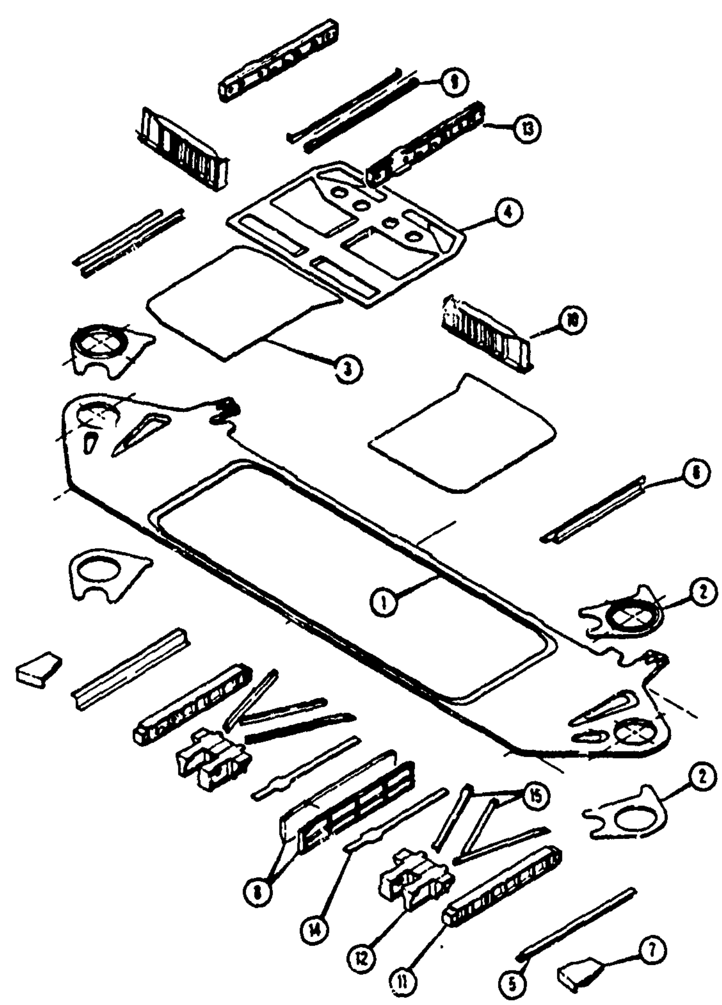
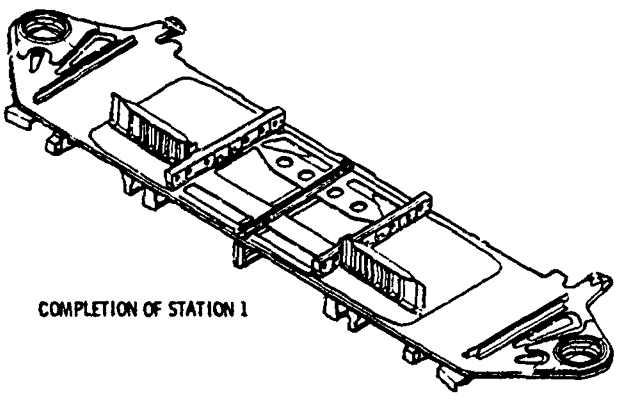


Figure 4.2.2-1 ASSEMBLY SEQUENCE

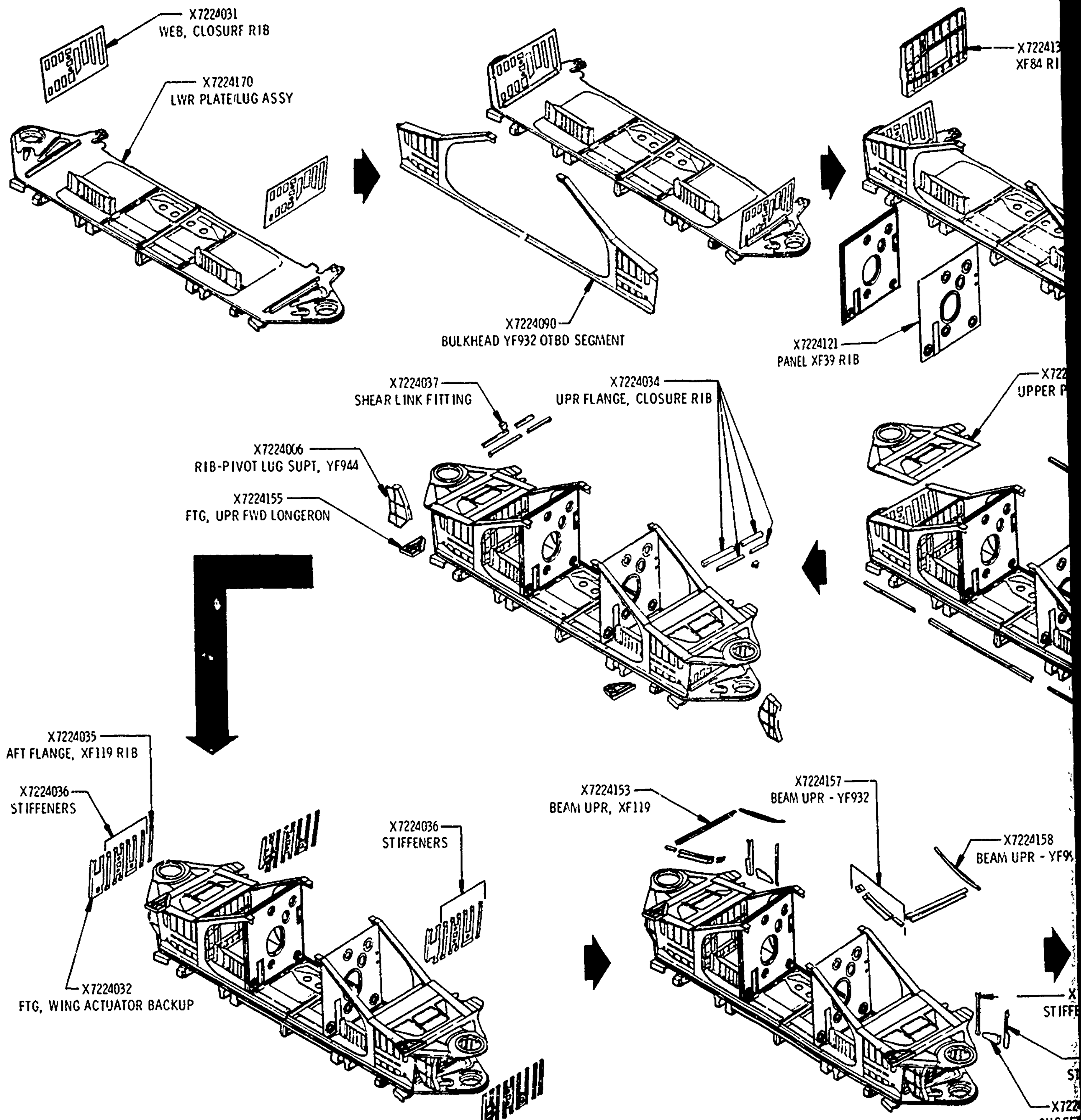




COMPLETION OF STATION 1

ITEM	PART NUMBER	DESCRIPTION
1	X7224175-7	LOWER LUG
2	X7224176	REINFORCING PLATE
3	X7224172	PANEL, X_F38-84
4	X7224173	CENTER PANEL
5	X7224163	LWR FAIRING SUPT X_F119
6	X7224033	LWR FLANGE X_F119
7	X7224050	LWR FWD LONGERON FTG
8	X7224118	LWR ℄ LONGERON
9	X7224113	LWR FLANGE, ℄ RIB
10	X7224181	SUPT, DRAG BRACE FTG
11	X7224174	LWR FAIRING SUPPORT X_F95.5
12	X7223941	DRAG BRACE FTG
13	X7224122	LWR ATTACH MEMBER, X_F39 RIB
14	X7224126	LWR STRAP, XF39
15	X7224182	STIFFENERS, LWR PLATE

Figure 4.2.2-2 STATION 1 - LOWER PLATE ASSEMBLY SEQUENCE


X7224031
WEB, CLOSURE RIB
X7224170
LWR PLATE/LUG ASSY
X7224090
BULKHEAD YF932 OTBD SEGMENT
X7224121
PANEL XF39 RIB
X7224037
SHEAR LINK FITTING
X7224034
UPR FLANGE, CLOSURE RIB
X7224006
RIB-PIVOT LUG SUPT, YF944
X7224155
FTG, UPR FWD LONGERON
X7224035
AFT FLANGE, XF119 RIB
X7224036
STIFFENERS
X7224036
STIFFENERS
X7224032
FTG, WING ACTUATOR BACKUP
X7224153
BEAM UPR, XF119
X7224157
BEAM UPR - YF932

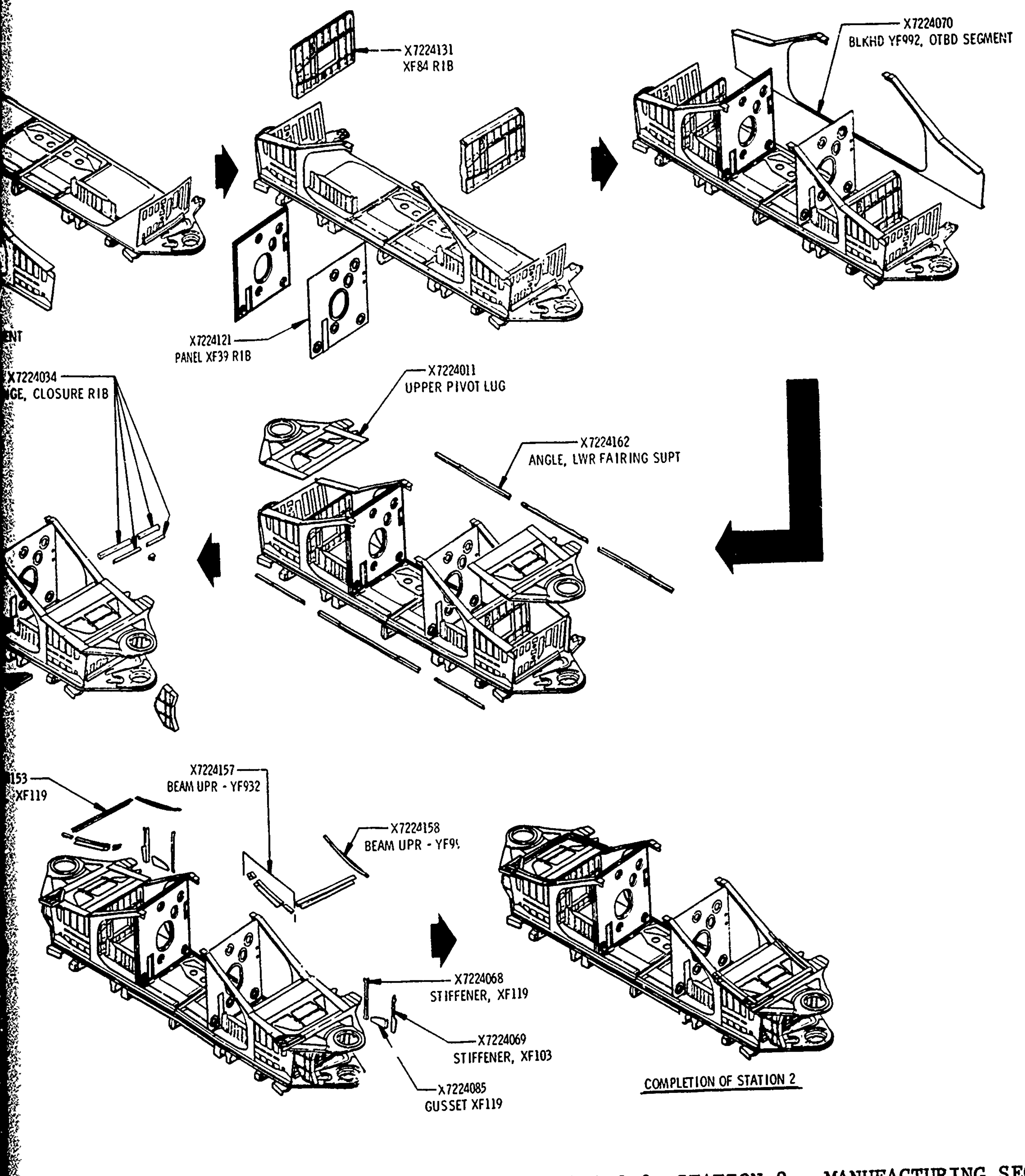


Figure 4.2.2-3 STATION 2 - MANUFACTURING SEQUENCE

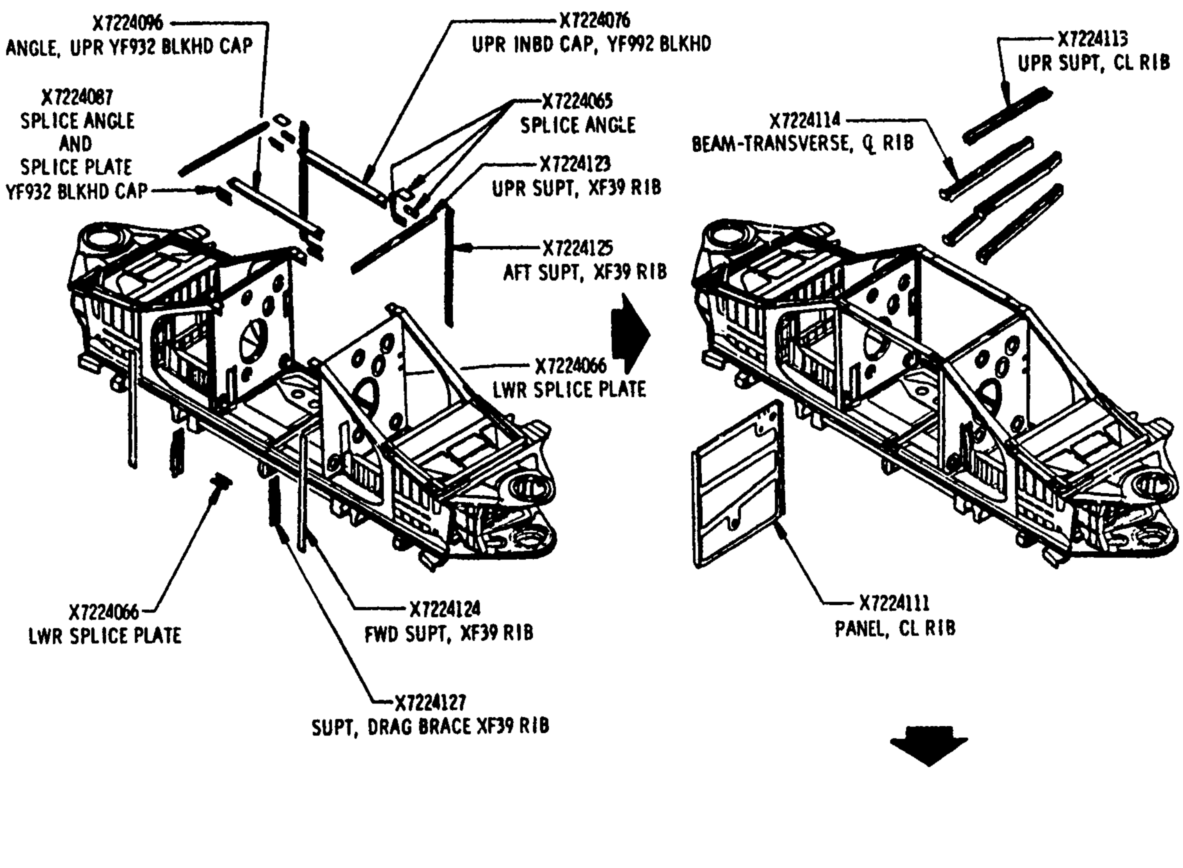


Figure 4.2.2-4 STATION 3 - MANUFACTURING SEQUENCE

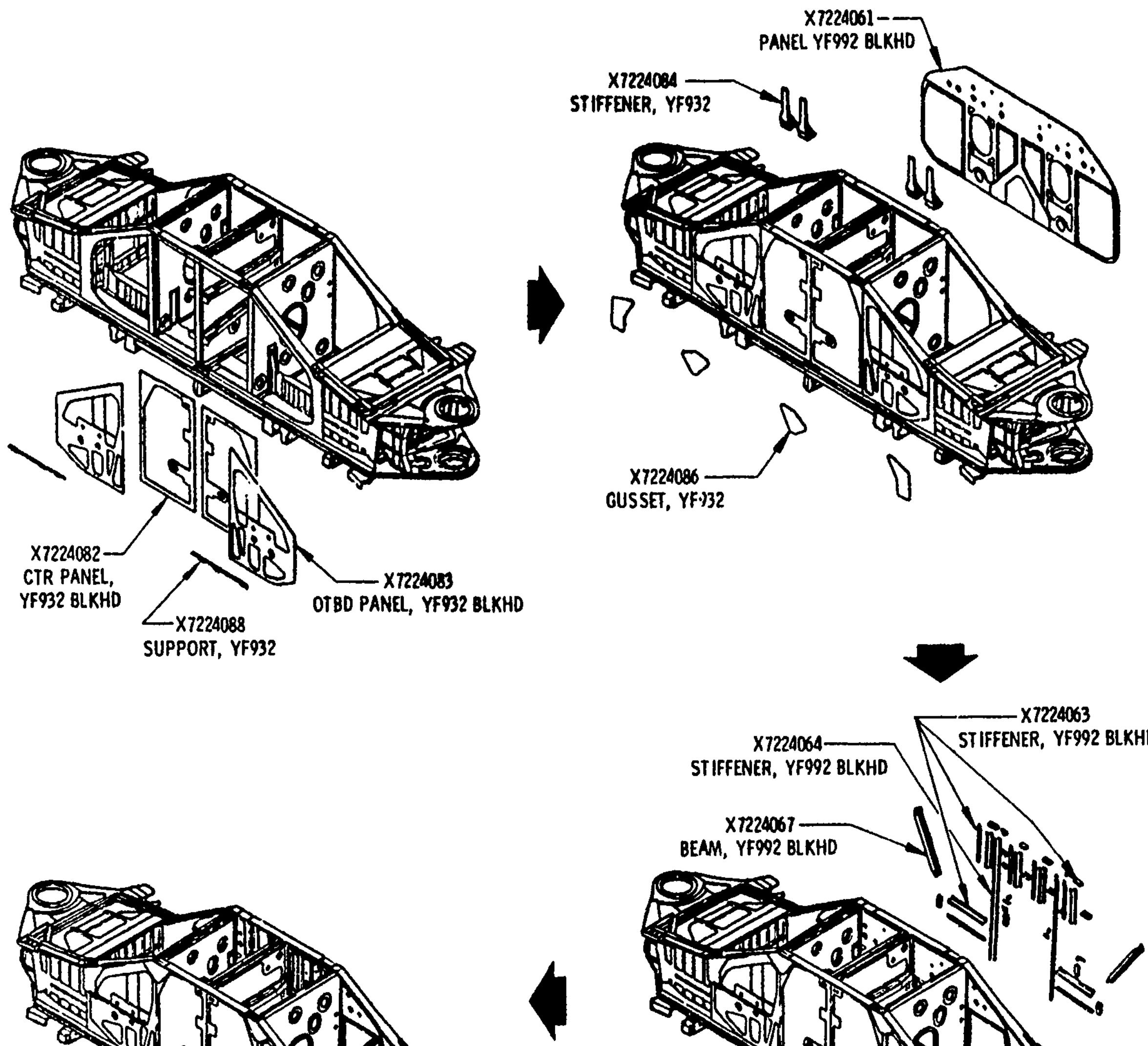


Figure 4.2.2-5 STATION 4 - MANUFACTURING SEQUENCE

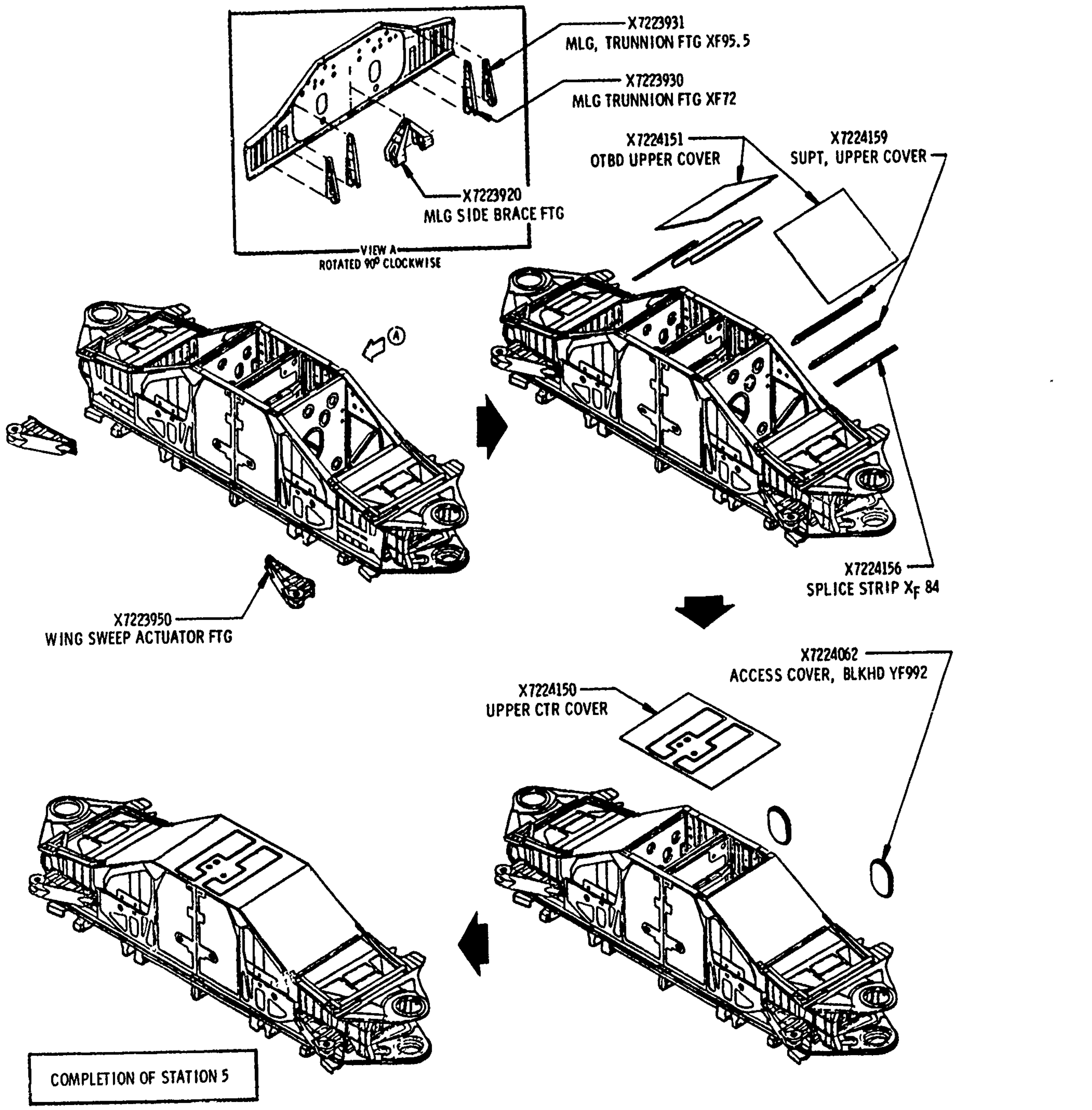


Figure 4.2.2-6 STATION 5 - MANUFACTURING SEQUENCE

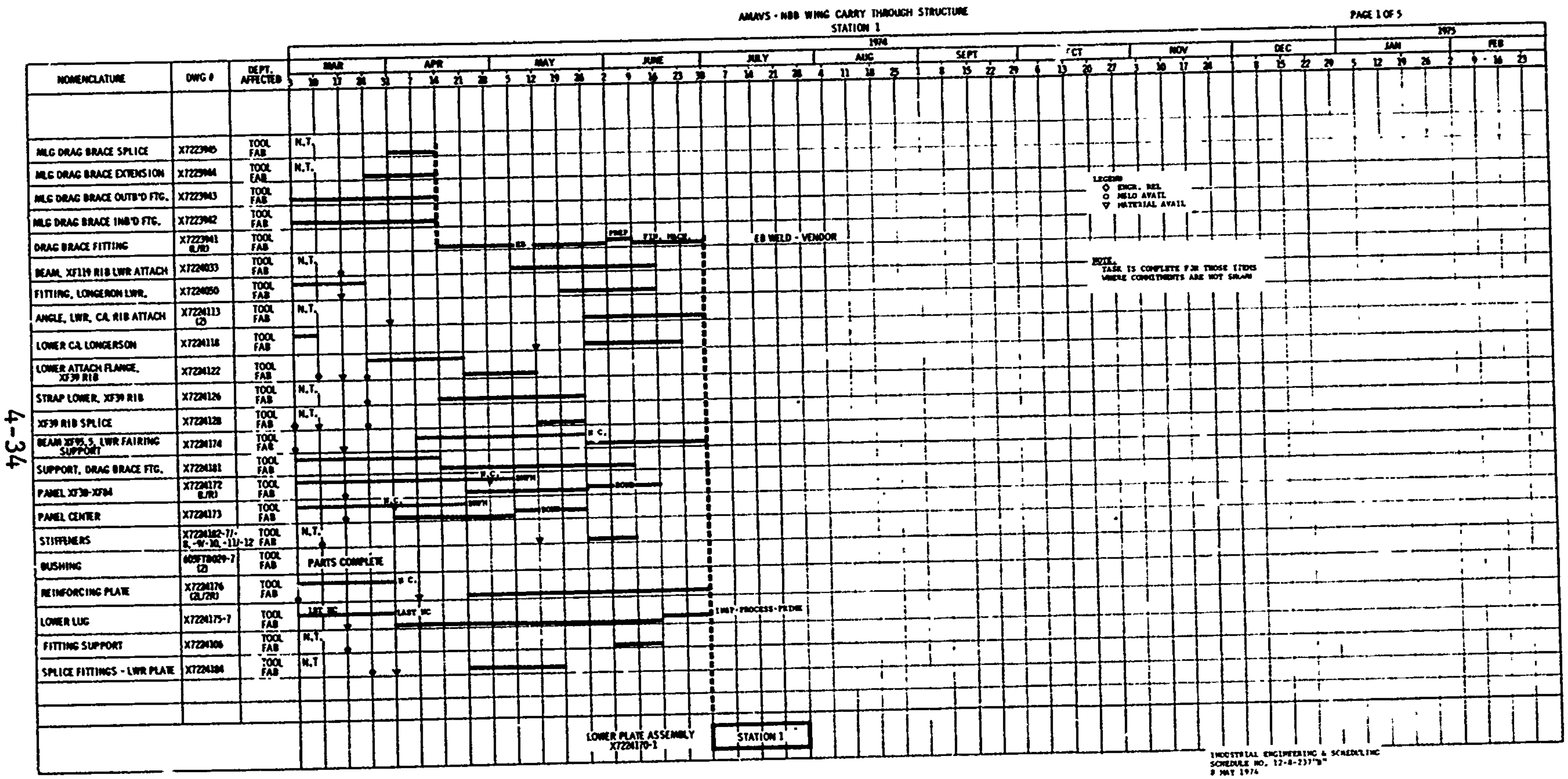


Figure 4.2.2-7 STATION 1 SCHEDULE

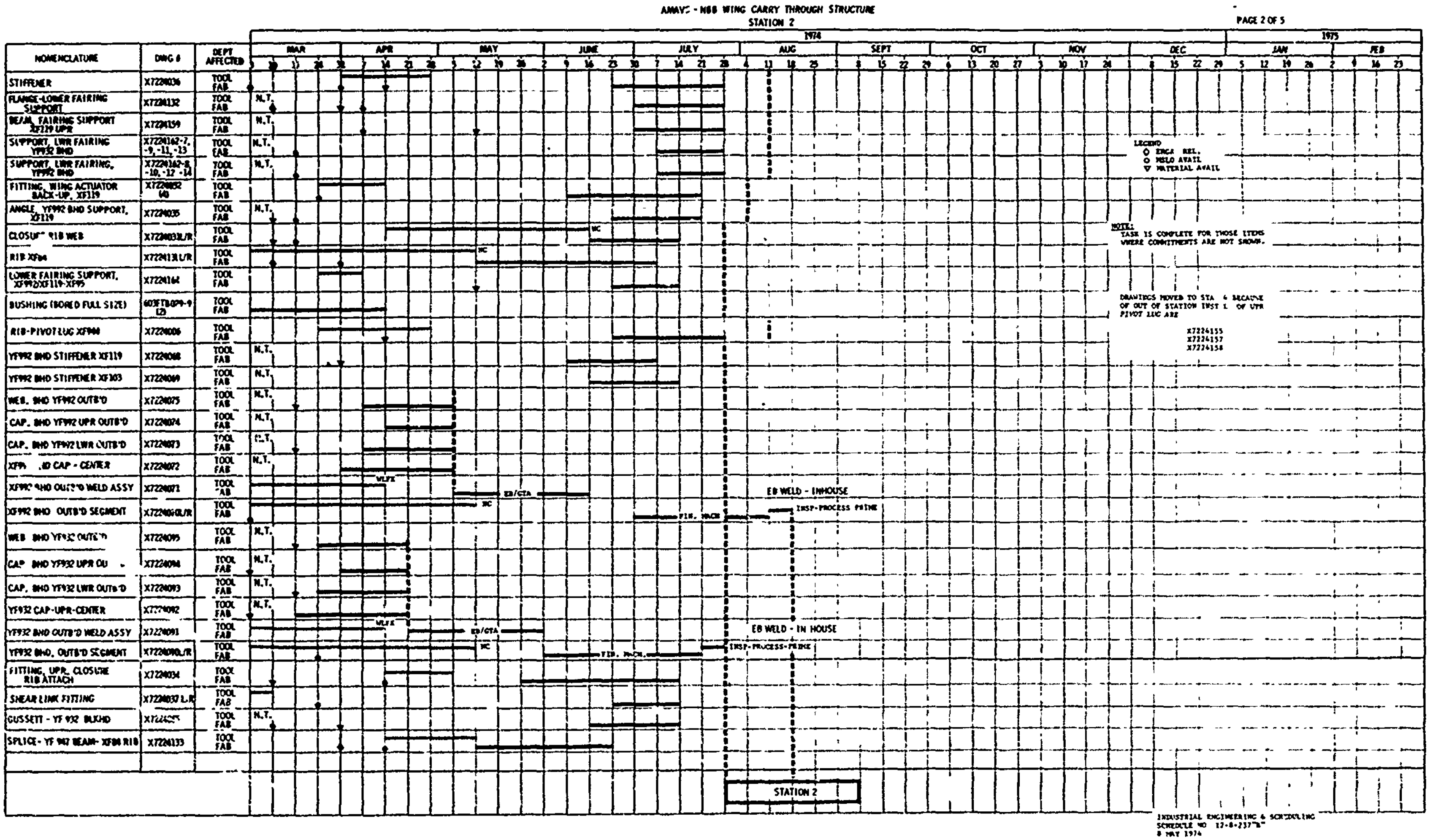


Figure 4.2.2-8 STATION 2 SCHEDULE

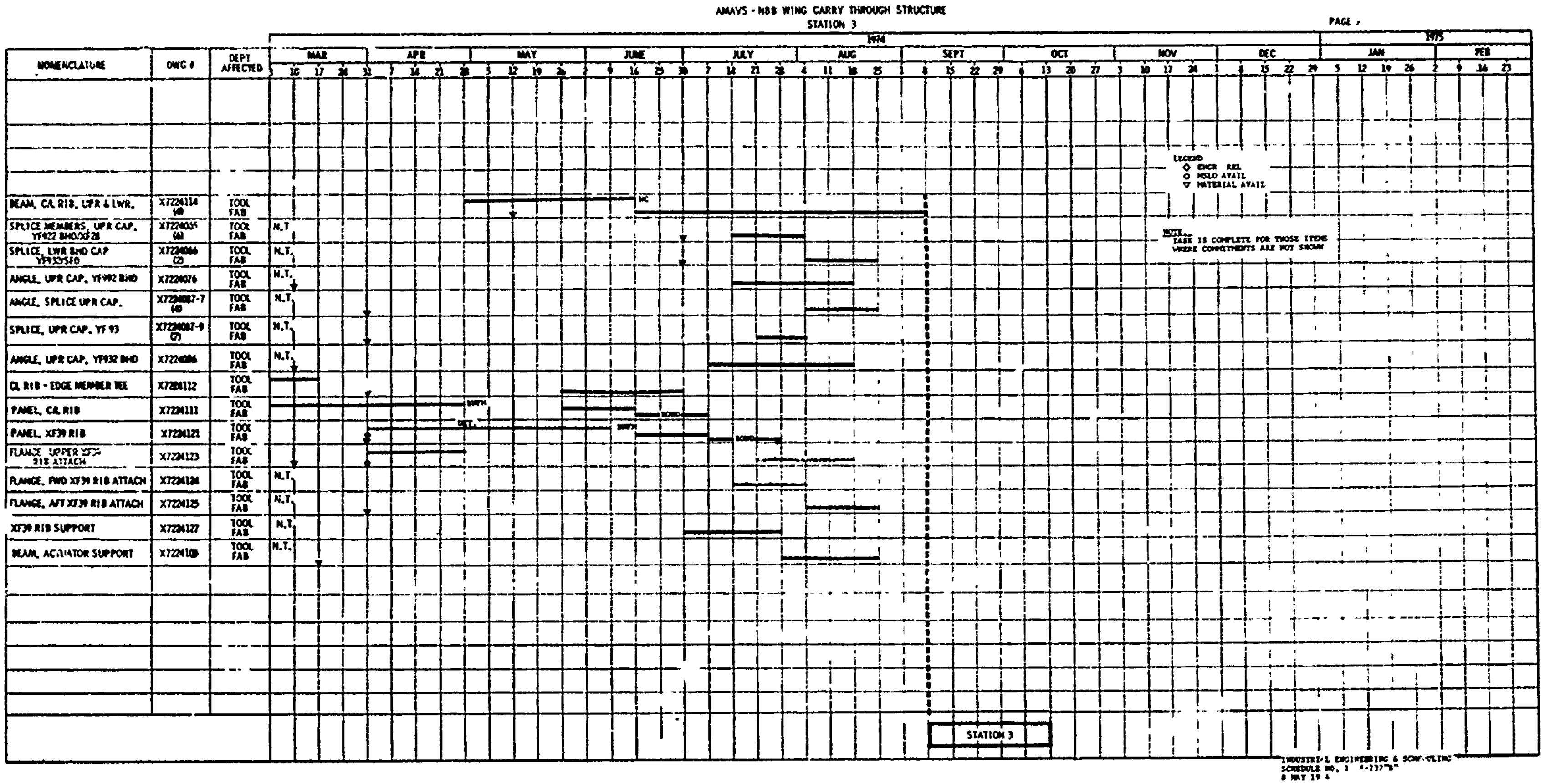


Figure 4.2.2-9' STATION 3 SCHEDULE

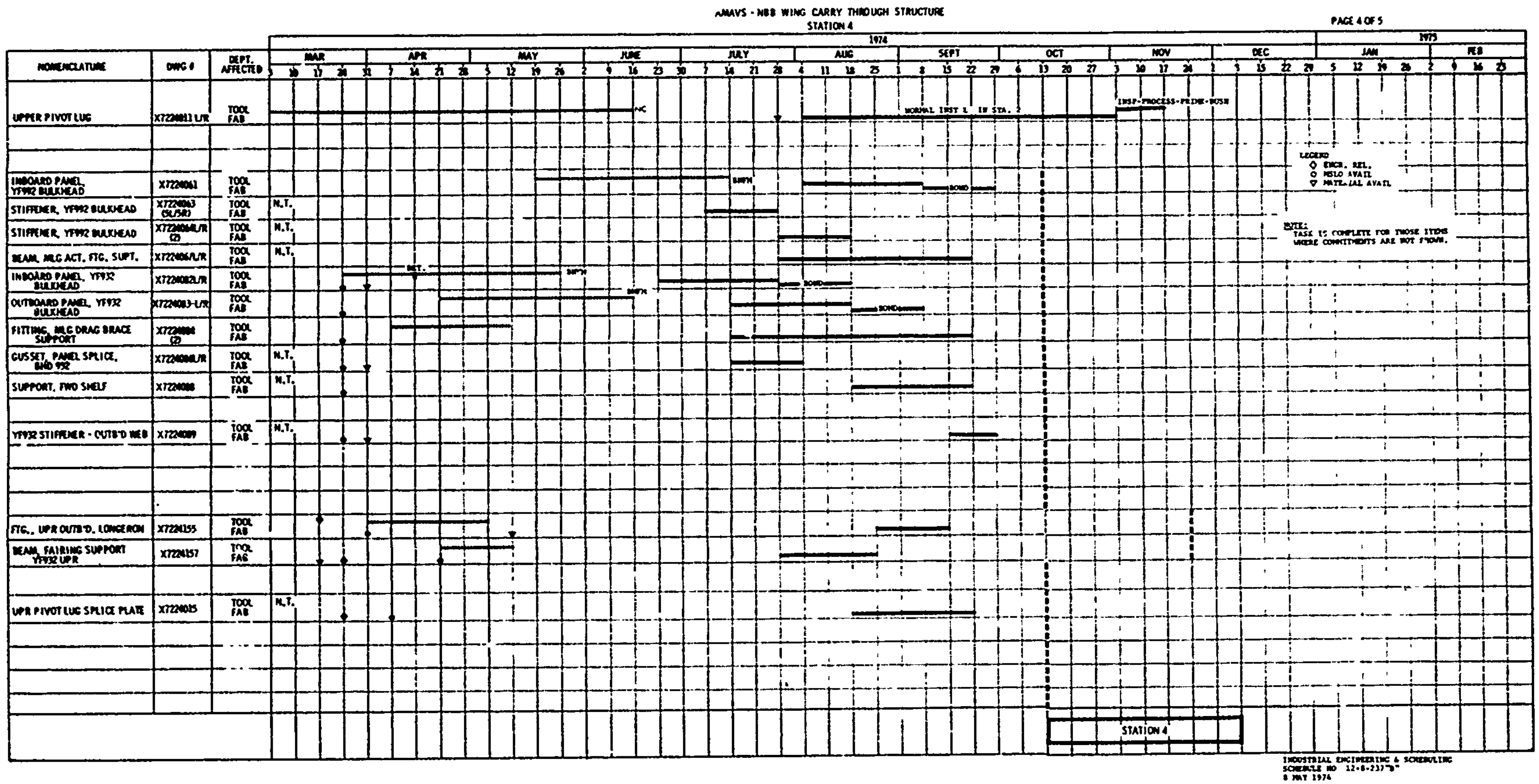


Figure 4.2.2-10 STATION 4 SCHEDULE

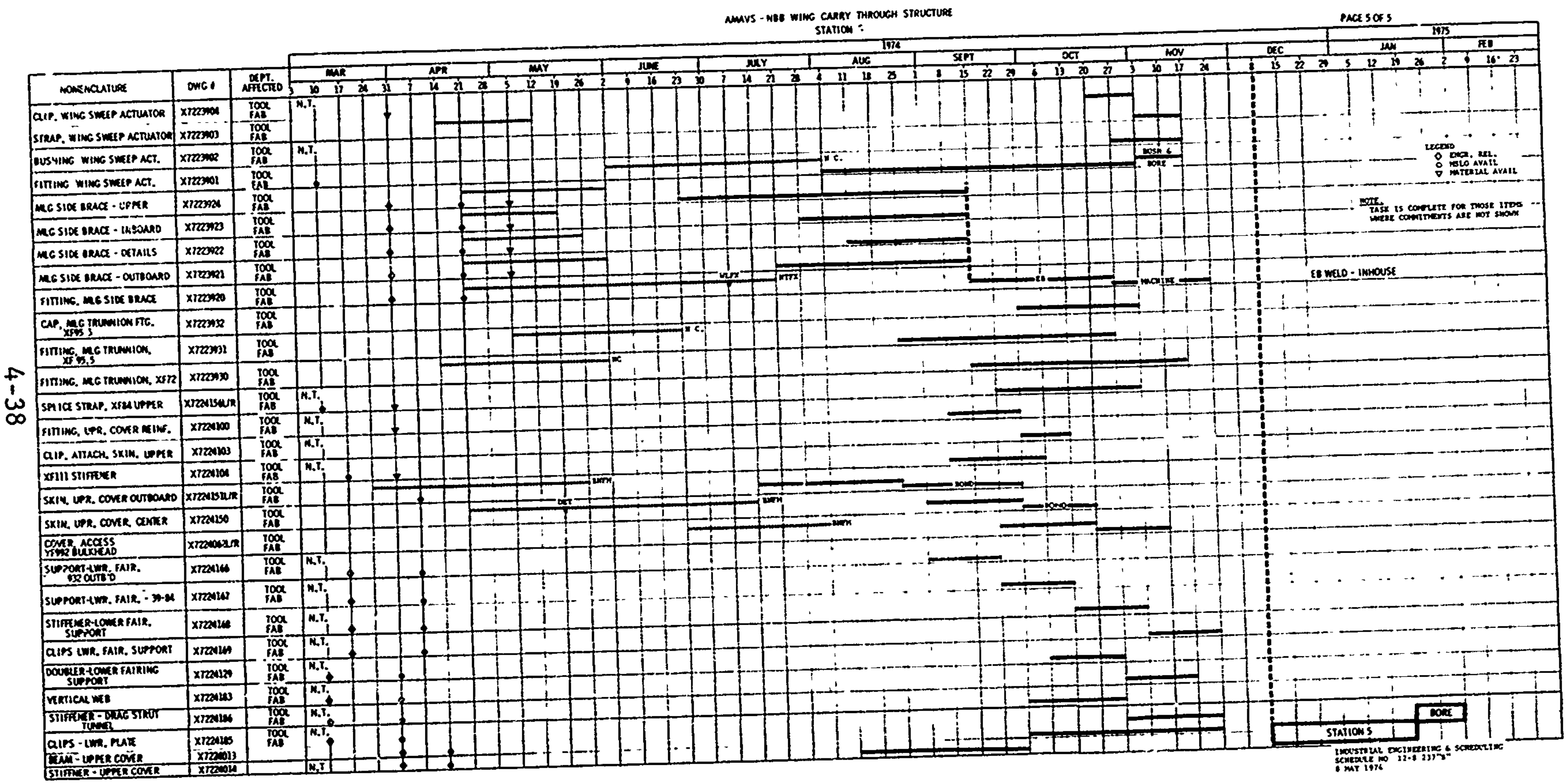


Figure 4.2.2-11 STATION 5 SCHEDULE

The PMA forms were prepared by manufacturing engineers as a part of design and trade study activity. A typical PMA of a detail part is shown in Figure 4.2.3-1. As a minimum the forms contained the following basic information.

1. Starting material size and condition
2. Manufacturing process
3. Special machines as required
4. Tool requirements
5. Estimated cost of tooling in hours
6. Estimated cost of part fabrication in hours

Estimates of cost were coordinated with industrial engineers for overhead rates and allocations. Tooling departments prepared estimates for planning, design, and fabrication of support tooling. Fabrication departments supplied detail parts and assembly estimates.

Cost data was compiled for major components and total WCTS. These estimates became the basis of budgets and manloading for manufacture of the one test article.

4.2.4 Manufacturing Engineering Coordination

A manufacturing research and development engineer was assigned as a manufacturing engineering project coordinator for all fabrication of the WCTS and related simulated fuselage sections. The coordinator was assigned manufacturing specialists to perform coordination tasks in the prime areas of (1) stock cut-off, sheet metal fabrication, sub-assembly, and adhesive bonding; (2) machine shop and welding including sub-contract welding, (3) tool fabrication and cost control, and (4) fastener hole preparation and final assembly. These special coordinators were made responsible for activities from engineering, planning, and fabrication and were permitted to draw on other manufacturing talent for support as required.

4.2.5 Tool Planning and Design

A select group of tool planning and tool design personnel was co-located in an area adjacent to design engineers, quality assurance engineers, and factory coordinators. The planning group was comprised of specialists for planning sheet metal details, machined details, weldments, adhesive bonding, and assemblies. A special group for numerical control planning and tape programming

PRELIMINARY MANUFACTURING ANALYSIS

Sheet 1 of 1
Date ______

PART NO. X7224176-7/8 CHANGE A N/A DASH NO. X7224170

NAME REINFORCEMENT - PIVOT LUG, LOWER REQ. PER A/C 1/1

MATERIAL 2.00 - FMS 1111 - 10N1 PROD. QTY. 1

MANUFACTURING PROCESS MACH FROM PLATE METHOD NO. 1

	DEPT	FAB-HRS	SPAN
1. FLAME CUT PER MAP C-1-3-2 (-3)	41	5HRS	
2. MILL ONE SURFACE TO MIN CLEAN UP	30	230 HRS	
3. MILL OPPOSITE SIDE TO HOLD 1.15 DIM	30		
4. DRILL TOOLING HOLES - N/C PPTA	30		
5. ROUGH & FINISH MILL COMPLETE PER B/P-N/C PRTA	30		
6. DRILL ATTACH HOLES .032 UNDER SIZE - N/C (28 HOLES) PPTA - USE FROM OPER #4	30		
7. DEBURR & HAND FINISH AS REQ'D	30		
8. # TAG	30		
9. INSP	275	30HRS	
10. APPLY B/P FINISH	41		
11. INSP	275		
12 F.S.	22		
TOOLING ESTIMATE			
PRTA = 142 HRS			
PPTA = 18 HRS			

Figure 4.2.3-1 COST ANALYSIS OF LOWER PIVOT LUG REINFORCEMENT

was retained in their original location due to accessibility to computers.

A special-assembly tool design team was established to work in conjunction with an assembly tool planner, the assembly specialist assigned to project coordination, and other coordinating personnel assigned to the program. The team designed minimum assembly and coordination tooling required for the WCTS and the forward and aft simulated fuselage assemblies.

Tool manufacturing estimators made cost estimates as tool designs were released for fabrication to be sure that tools, as designed, did not exceed the budgeted cost.

4.2.6 Fastener Holes - Numbering and Planning for Special Tools - WCTS

Assembly of the WCTS will require approximately 6500 fasteners. Approximately 1500 of these will be taper-lok bolts. Installations of fasteners will require many combinations of power fed drilling and reaming equipment. Special drills and reamers of assorted sizes and lengths and specially designed drill plates with adaptors for accepting the drilling equipment will be needed.

A new procedure related to hole preparation and fastener installation was devised for fabrication of the WCTS. The basic plan was to install a numbering system for all holes and related fasteners. Each hole would be treated much in the same manner as a detail part during tool planning, hole preparation, and fastener installation.

Implementation of the system was a joint effort between manufacturing engineers and design engineers with manufacturing engineers establishing the actual hole numbers as a function of the tool planning task. Responsibility for maintaining the system will be transferred to design engineering at the completion of all engineering drawings. In general the procedure is as follows.

1. Code each plane or surface as designated by engineering drawings as a major attach surface. Use alphabetic letters to identify each plane or surface.

2. Assign odd numbers (1, 3, 5, etc.) to fastener holes of a designated plane of the engineering drawing. The corresponding even numbers (2, 4, 6, etc.) becomes the right hand hole for the

opposite hand part as in conventional aircraft part numbering.

3. Manufacturing engineers are responsible for assigning hole numbers at the pre-design level. A master numbered copy of each fastener installation drawing will be furnished to the master layout (MSLO) group of engineering. The MSLO group will show all related details in the designated plane and each fastener location will carry the plane code and hole number such as A1, A3, A5, etc.

4. The completed full size MSLO drawings will be reduced to conventional blue print size and given engineering drawing numbers for normal blue print distribution. Changes and revisions to hole patterns after initial release of the numbered holes will be maintained by design engineering.

Planning functions of manufacturing engineers will utilize the hole numbers in preparing hole preparation data sheets. The data sheet as shown in Figure 4.2.6-1 contain cutting tools, hole indexing systems, and tool kit requirements. This information is used to determine make, buy, or requisition from stock needs.

Tool planning and design paper uses the hole numbers to identify holes being drilled by special tools and kits.

Production assemblers and quality control engineers will utilize the hole numbers in the installation, rework, and "buy-off" procedures.

The basic planes of the WCTS as identified by alphabetic letters are as follows.

A - Lower Plate
B - Closure Rib
C - Y_F932 Bulkhead
D - X_F84 Rib
E - X_F992 Bulkhead
F - X_F39 Rib
G - X_F0 Rib
H - Upper Pivot Plate
J - Upper Outboard Cover Panel
K - Upper Center Cover Panel

4.2.7 Make-or-Buy Decisions for Electron Beam Welding

All electron beam weldments were candidates for sub-contracting. The four parts in this category were (1) X7223941 Drag Brace Fitting, (2) X7224091 Y_F932 Bulkhead, (3) X7224071 Y_F992 Bulkhead,

HOLE PREPARATION

X7224060

HOLE NO. LH	HOLE NO. RH	FASTENER NUMBER AND SIZE	GRIP	GP.	WASHER ON HEAD SIDE	MATERIAL	HEAD LOCATE *	MTL THK	INSTALL PER	"H" DIM. MAX.	"H" DIM. MIN.
E1	E2	X7223999-6	10	1	81755/ P511-10	TI-NI-NI	N	.50	X7223993-6	.330	.186
E3	E4		10			TI-NI-NI		.50			
E5	E6		8			TI-NI		.38			
E7	E8										
E9	E10	X7223999-6	8	1	81755/ P511-10		N	.38	X7223993-6	330	.18
E11	E12	X7223985-6	8	1			N	.45	X7223983-6	--	--
E13	E14	X7223985-6	8	1			N	.45	X7223983-6	--	--
E15	E16	X7223999-6	9	1	81755/ P511-10		N	.45	X7223993-6	.330	.18
E17	E18	X7223999-6	9	1	81755/ P511-10		N	.45	X7223993-6	.330	.18
E19	E20	X7223985-6	8	1	--		N	.45	X7223983-6	--	--
E21	E22										
E23	E24										
E25	E26	X7223985-6	8	1	--		N	.45	X7223983-6	--	--
E27	E28	X7223999-6	8	1	81755/ P511-10		N	.38	X7223993-6	.330	.18
E29	E30										
E31	E32	X7223999-6	8	1	81755/ P511-10	TI-NI	N	.38	X7223993-6	.330	.18

*DRILL FROM OUTSIDE OF BOX

PARATION DATA SHEET

"H" DIM. MAX.	"H" DIM. MIN.	"P" DIM. MAX.	"P" DIM. MIN.	DRILL SIZE	REAM SIZE	STANDARD BOLT COBALT REAMER	STANDARD BOLT CARBIDE REAMER	FIRST REPAIR COBALT REAMER	FIRST REPAIR CARBIDE REAMER	SECOND REPAIR COBALT REAMER	SECOND REPAIR CARBIDE REAMER
.330	.186	.259	.115	.3594	--	CJ2080 -1-6 .3837	CJ825 -3/8-1-2 .3857	TPRHS -7 .3993	CJ825 -3/8-1-2 .4013	TPRHS -7 .4149	CJ825 -3/8-3-4 .4169
.330	.186	.259	.115			CJ2080 -1-6 .3837	CJ825 -3/8-1-2 .3857	TPRHS -7 .3993	CJ825 -3/8-1-2 .4013	TPRHS -7 .4149	CJ825 -3/8-3-4 .4169
--	--	.259	.115			CJ2074 -1-6	CJ825 -3/8-1-2	CJ2074 -2-6	CJ825 -3/8-1-2	CJ2074 -3-6	CJ825 -3/8-3-4
--	--	.259	.115			CJ2074 -1-6	CJ825 -3/8-1-2	CJ2074 -2-6	CJ825 -3/8-1-2	CJ2074 -3-6	CJ825 -3/8-3-4
.330	.186	.259	.115			CJ2080 -1-6 .3837	CJ825 -3/8-1-2 .3857	TPRHS -7 .3993	CJ825 -3/8-1-2 .4013	TPRHS -7 .4149	CJ825 -3/8-3-4 .4169
.330	.186	.259	.115			CJ2080 -1-6	CJ825 -3/8-1-2	TPRHS -7	CJ825 -3/8-1-2	TPRHS -7	CJ825 -3/8-3-4
--	--	.259	.115			CJ2074 -1-6	CJ825 -3/8-1-2	CJ2074 -2-6	CJ825 -3/8-1-2	CJ2074 -3-6	CJ825 -3/8-3-4
--	--	.259	.115			CJ2074 -1-6	CJ825 -3/8-1-2	CJ2074 -2-6	CJ825 -3/8-1-2	CJ2074 -3-6	CJ825 -3/8-3-4
.330	.186	.259	.115			CJ2080 -1-6 .3837	CJ825 -3/8-1-2 .3857	TPRHS -7 .3993	CJ825 -3/8-1-2 .4013	TPRHS -7 .4149	CJ825 -3/8-3-4 .4169
.330	.186	.259	.115	.3594	--	CJ2080 -1-6	CJ825 -3/8-1-2	TPRHS -7	CJ825 -3/8-1-2	TPRHS -7	CJ825 -3/8-3-4

BOX

Figure 4.2.6-1 HOLE PREPARATION DATA SHEET and (4) X7223920 MLG Side Brace Fitting.

Production schedule dictated early requirements for the X722 3941 Drag Brace Fitting. The material being 6Al-4V titanium alloy presented no major research and development problems. Size of the part was outside the limits of in-house electron beam welding equipment. An early decision was made to sub contract the two units (left and right hands) and the contract was negotiated with Murdock Machine and Engineering Company, Irving, Texas.

The X7224091 and X7224071 bulkheads are weldments of 10 Nickel steel. Weldability of this materialwas not well known. Welding evaluations and developments were conducted in-house earlier in this program for both GTA and EB welding. After exploring outside capabilities, it was decided to utilize development data and make all weldments in house for the one test unit. A design change was made on the X7224091-7/8 and X7224071-7/8 (web to lower cap) assemblies changing the weld process from EB to GTA. The decision was based on the need for only one weldment of each dash number and weld tooling for the upper GTA weld could be adaptable to the lower weldment without added tooling cost.

The EB welding task for joining two sections of the upper tee caps of the bulkheads presented several problems for in-house production. The existing EB chamber would not accommodate this size part. Development of weld parameters for the 1.80 inch thick tee section had not been completely tested for reliability due to shortage of material during the development phases. The decision was made to rework the EB welding chamber by adding extensions on each chamber door to increase the maximum length to approximately 100 inches. Additional funds were authorized, test material was obtained, and testing was conducted to a satisfactory level to proceed with production welding.

It should be pointed out at this time that EB welding would not be considered for the tee cap joint in a production contract of 40 or more units. A conventional forging is considered more economical since 4 forgings per aircraft would be required for the 4 bulkhead rails. Forgings would be for full rail lengths thereby eliminating the weld joint. Additional savings in machining would be obtained from forgings.

A decision is pending, favoring a sub contract for EB welding the 6Al-4V titanium MLG Side Brace Fitting. The fitting is scheduled for installation in station 5 which allows significant lead time for fabrication.

4.3 SIMULATED FUSELAGE TOOL PLANNING AND DESIGN

The manufacturing plan and schedules for the WCTS included fabrication of the forward and aft sections of the simulated fuselage and the coordination tools required for mating the three major sections. Figure 4.3-1 shows breakout of simulated fuselage components and the simulated WCTS. The simulated WCTS was considered to be a coordinating gage and was assigned a nomenclature of tool accessory (TOAC). The basic function of the TOAC is to coordinate fore and aft longeron attachments. It also simulates the wing pivot pin locations.

Standard prototype planning was issued for all details and assemblies of the simulated fuselage sections. Details were made without benefit of special tools. Temporary form blocks were used to form the frame details in the forward section. Assembly of the fuselage sections will be made by positioning the longerons to the TOAC and the respective forward or aft bulkhead which is to be tool located in relation to the TOAC.

4.4 TOOL FABRICATION

As previously stated a minimum tooling concept was adopted for this program. The major tools necessary to coordinate, assemble, weld and bond are described below.

4.4.1 X7224000 Tool Accessory (TOAC)

This tool is described in Section 4.3 as the tooling gage between the test article and the fuselage sections.

4.4.2 X7224000 Coordinating Fixture (COFX)

This fixture establishes the longeron locations at Y_F850 and Y_F1050 stations for mating with the forward and aft test structure. See Figure 4.4.2-1.

4.4.3 X7224170 Drill Fixture (DRFX)

The lower plate is positioned vertically in this fixture for ease in drilling and installing taper-lok fasteners in a horizontal position with access to both sides of the plate. The DRFX structure is shown in Figure 4.4.3-1. All assembly work for planning station 1 will be done in this fixture.

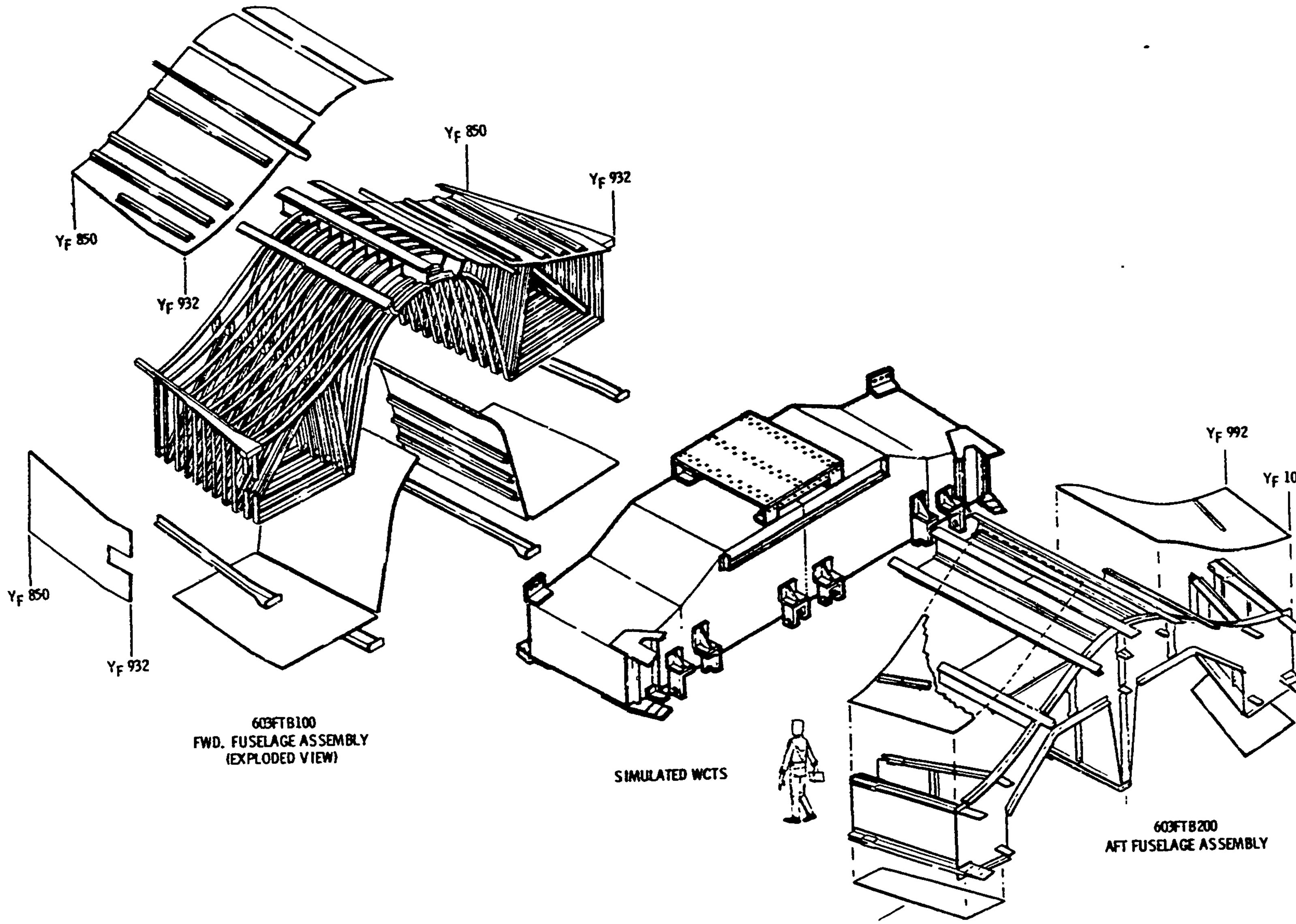


Figure 4.3-1 SIMULATED FUSELAGE BREAKDOWN

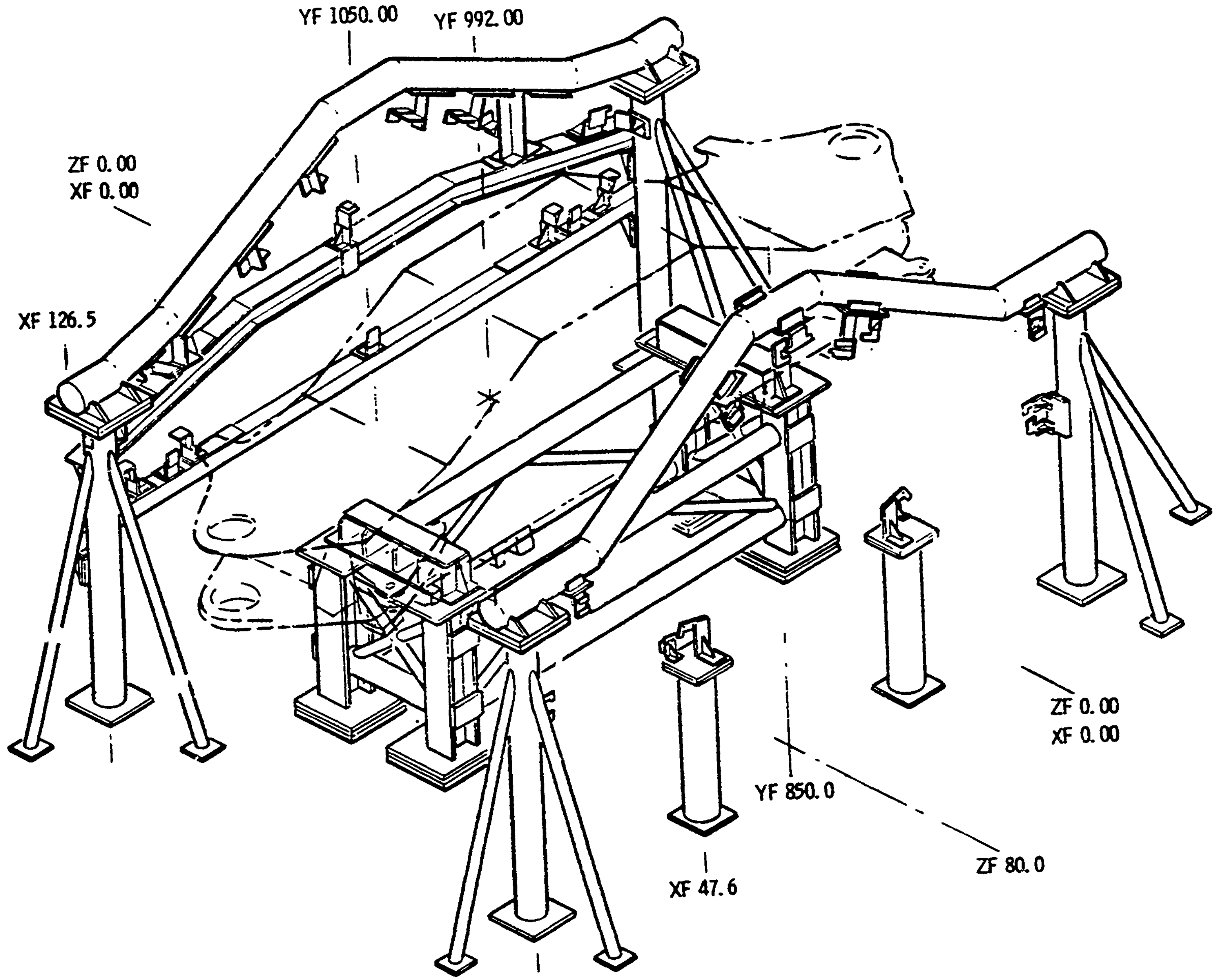


Figure 4.4.2-1 COORDINATING FIXTURE

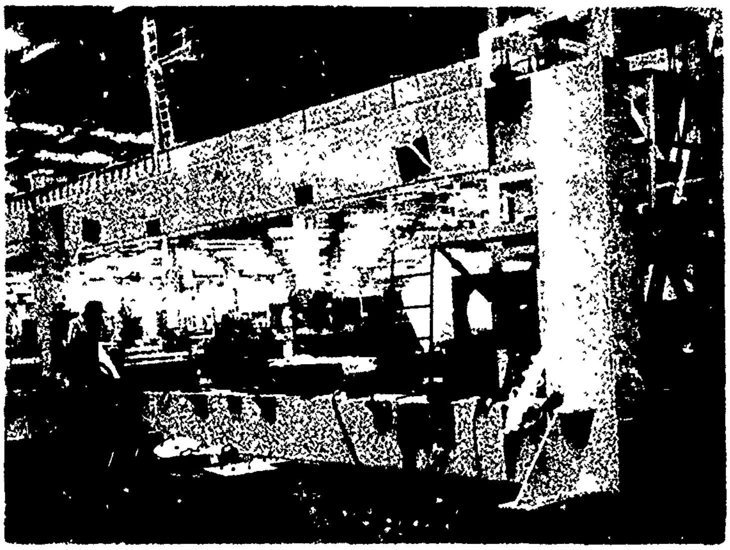


Figure 4.4.3-1 STATION 1 ASSEMBLY FIXTURE

4.4.4 X7224000 Coordinating Jig (COJ1)

All installations for planning station 2 through 5 will be performed in this COJ1. The lower plate assembly from station 1 acts as a base for the tool. All bulkheads and ribs locate to this lower plate. This tool locates the upper plates and lugs in relation to the pivot pin. Bushings in both upper and lower lugs will be undersize during assembly. The completed WCTS will be removed from the COJ1 and carried to the Gray boring mill for final sizing and line boring. Figure 4.4.4-1 shows proposed method to face and line bore bushings in upper and lower lugs. Figure 4.4.4-2 shows the COJ1 in fabrication with the TOAC being used to coordinate simulated fuselage interfaces.

4.4.5 X7224091 Bulkhead Cap Weld Fixture (WLFX) Electron Beam Weld

One fixture was made to prefit and hold the four upper cap bulkhead segments for welding. These are the left-hand and right-hand assemblies for the forward and aft bulkheads. Figure 4.4.5-1 shows the fixture with part loaded.

4.4.6 X7224091 Bulkhead Weld Fixture (WLFX) GTA Welding

A total of eight welds are made in this fixture. There are two welds approximately 60 inches long on each left-hand and right-hand segment of the two bulkheads. Weld thickness is .65 inch. Figure 4.4.6-1 shows the WLFX with bulkhead in welding position.

4.4.7 MLG Drag Brace Fitting Electron Beam Weld Fixture

This fixture was made for both left-hand and right-hand parts and for use in the electron beam welding chamber at Murdock Machine and Engineering Company in Irving Texas. Design and fabrication of the tool was coordinated with the sub contractor. Figure 4.4.7-1 shows the completed tool with parts fitted in the tool prior to shipment to the sub contractor.

4.4.8 Adhesive Bonding Tools - Bondforms (BNFM)

A total of ten parts will require BNFMs. All tools will be built on flat aluminum bases. A typical BNFM is one of 6061 aluminum as shown in Figure 4.4.8-1.

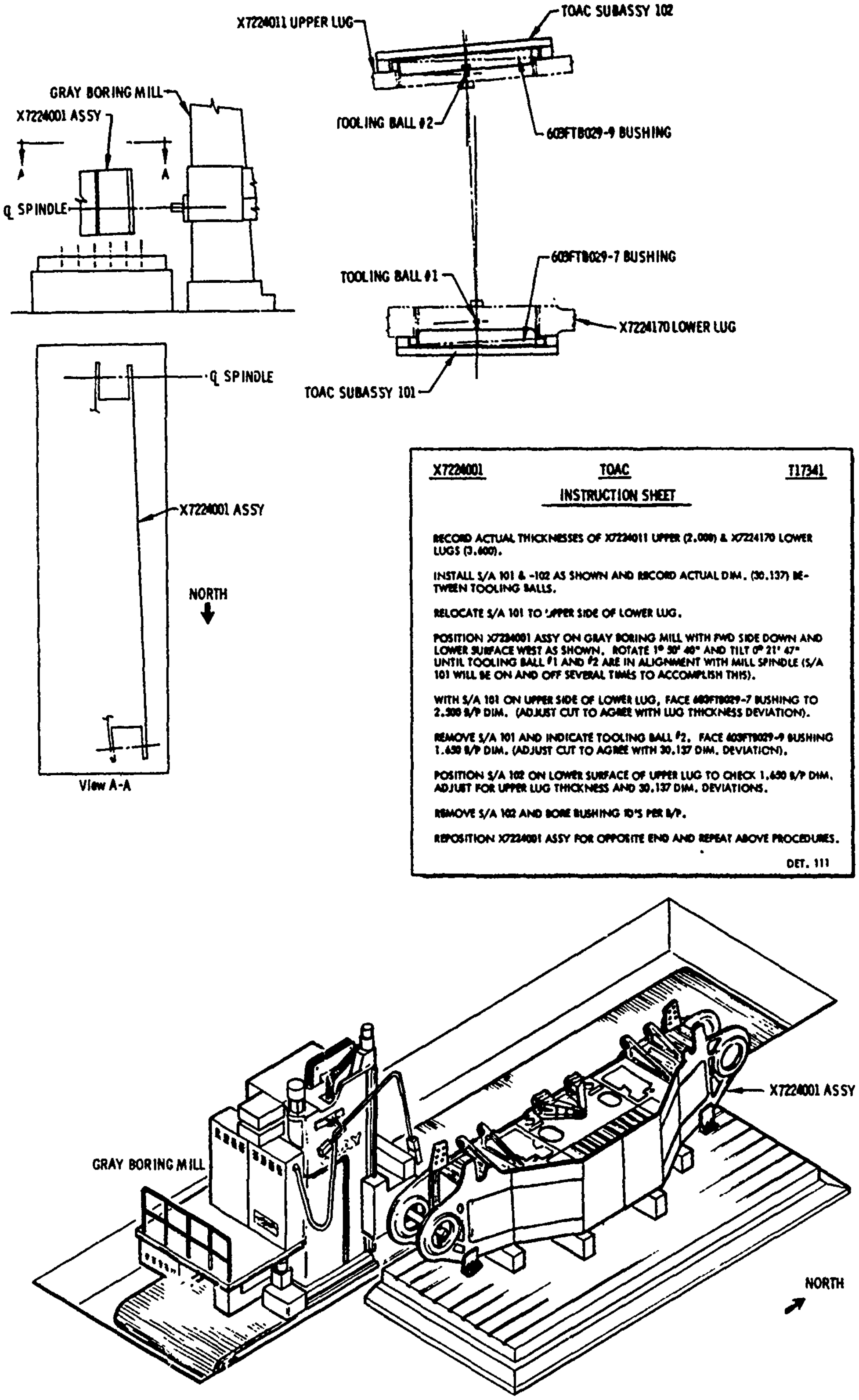


Figure 4.4.4-1 LINE BORE WING PIVOT LUGS

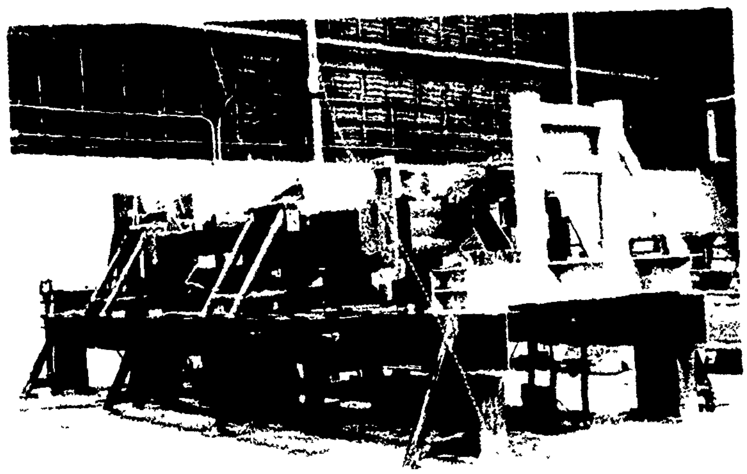


Figure 4.4.4-2 WING CARRY THROUGH STRUCTURE ASSEMBLY FIXTURE STRUCTURE AND DUMMY WCTS COORDINATING TOOL

Figure 4.4.5-1 ELECTRON BEAM WELD FIXTURE AND UPPER CAPS

Figure 4.4.6-1 GTA WELDING FIXTURE WITH BULKHEAD

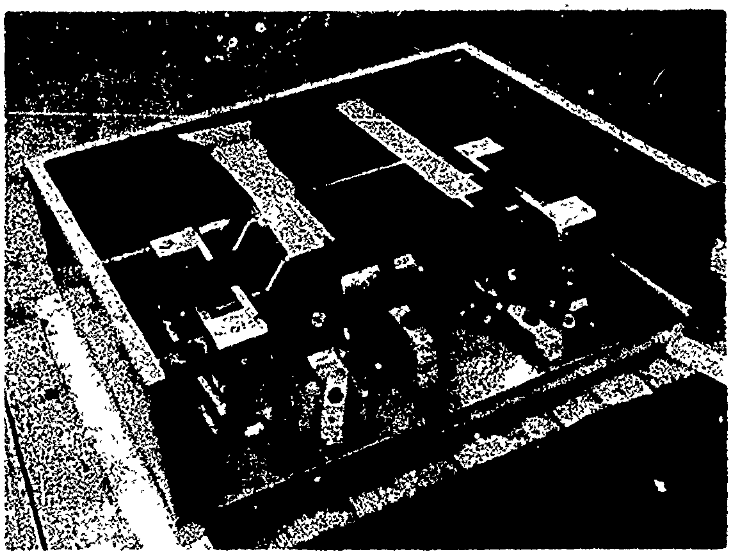


Figure 4.4.7-1 DRAG BRACE FITTING WELDING TOOL WITH DETAILS LOADED

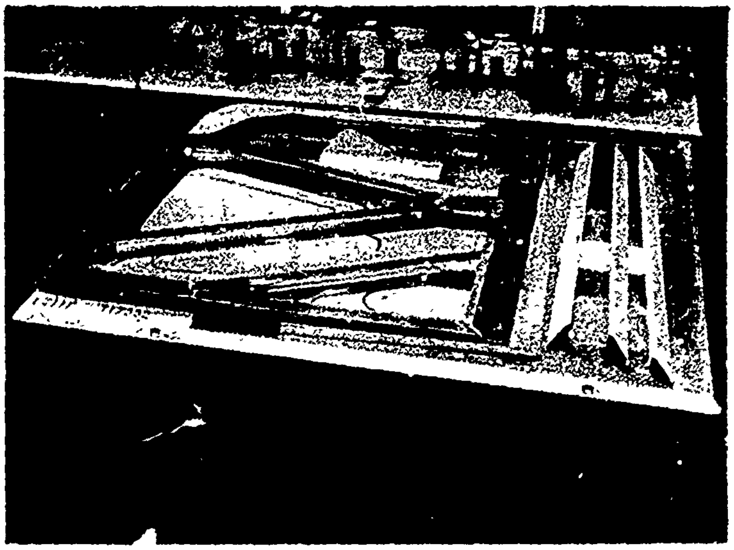


Figure 4.4.8-1 BOND FORM TOOLING FOR X7224172 LOWER PLATE BONDED PANEL, OUTBOARD

4.4.9 Numerical Controlled (N/C) Tapes

A total of 16 production N/C tapes were programmed for complex high-dollar parts. The parts are as follows:

1. X7223901 Wing Sweep Actuator Fitting
2. X7223930 X_F72 Trunnion Fitting
3. X7223931 $X_F95.5$ Trunnion Fitting
4. X7224011 Upper Plate Lug
5. X7224031 Outboard Closure Rib, Web
6. X7224061 Y_F992 Bulkhead Web, Inbd.
7. X7224070 Y_F992 Bulkhead, Welded Assembly
8. X7224083 Y_F932 Bulkhead Web, Inboard
9. X7224090 Y_F932 Bulkhead, Welded Assembly
10. X7224114 Beam, C_L Rib
11. X7224131 X_F84 Rib
12. X7224172 Lower Plate, Bonded Panel, Outboard
13. X7224173 Lower Plate, Bonded Panel, Center
14. X7224174 Lower Beam X_F95
15. X7224175 Lower Plate and Pivot Lug
16. X7224176 Lower Pivot Lug Reinforcement

The completed N/C tapes are being run in a simulated part of aluminum material as a method of checking their accuracy. The check-out of a bulkhead tape is shown in Figure 4.4.9-1.

4.5 PLANNING OF MATERIAL ALLOCATION PLANS (MAPS)

A unique material allocation plan (MAP) was installed during the design phases of this program. It was necessary to select and order raw materials for the program during Phase II because of eight months lead time. The MAP procedure was initiated whereby engineering designers were assigned a piece of material at the design level for fabrication. Scale drawings were made of each plate or sheet ordered for the program. These drawings became MAPs and as engineering drawings were assigned detail part numbers the size of the stock required to make each part, right and left hand, was drawn to scale and numbered on the appropriate MAP drawing. A typical MAP drawing is shown as Figure 4.5-1.

In addition to control of allocations of material the MAP provided other benefits. It provides the following basic information.

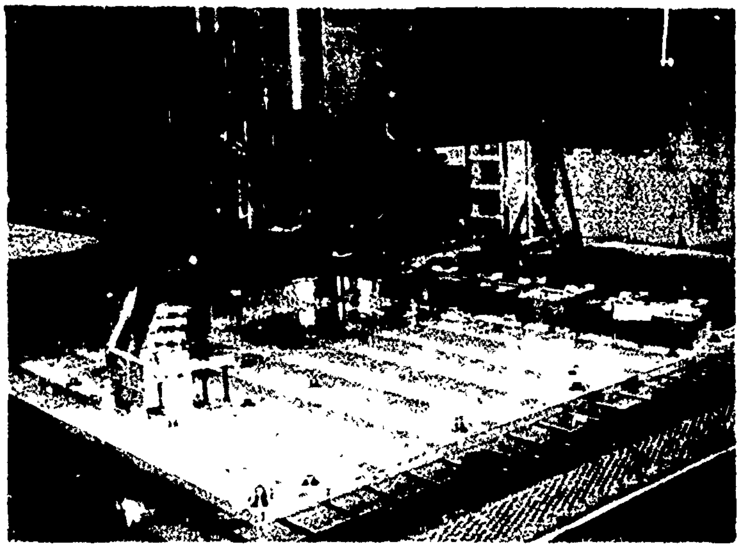
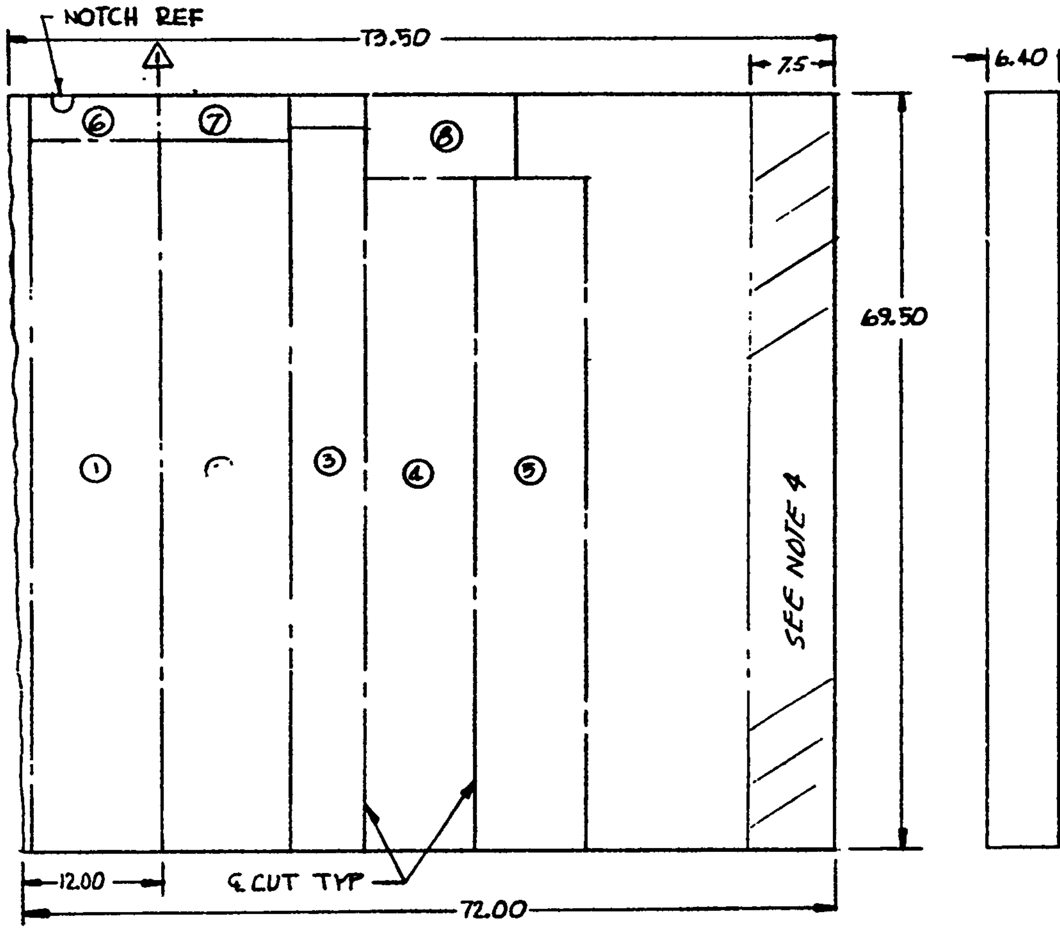


Figure 4.4.9-1 NUMERICAL CONTROL TAPE TRYOUT FORWARD BULKHEAD



REVISIONS			
SYM	DESCRIPTION	APPR	DATE
A SH 1	REDRAWN WITH CHANGES, PLATE SIZE WAS 6.4x66x70, ITEM ③ "D" WAS 66.00x6.28, ADDED NOTE 3		
B SH 1	REVISED "D" DIM ON ALL ITEMS ADDED NOTE 4 & 7.50 DIM		
C SH 1	ADDED ITEMS ⑥, ⑦ & ⑧ & NOTE 5		

5. ITEMS ⑥ & ⑦ USED FOR H.T. TENSILE COUPONS
4. ULTRA-SONIC INSP NOT ACCOMPLISHED IN THIS AREA DUE TO SURFACE CONDITION.
3. MAKE INITIAL CUT △
2. ALL ITEMS DIM. FOR FLAME CUT
1. ALL REMNANTS MUST BE IDENTIFIED WITH BASIC MAP NO.

NOTES (EXCEPT AS SHOWN)

TABLE I

ITEM	PART NO.	'D' (MAX)	'N' (MIN)	MATL TR NO.
①	X7224072-7	66.48x11.66	64.43x9.86	C-1-8-1
②	X7224072-7	66.48x11.66	64.43x9.86	C-1-8-2
③	X7224096-7	67.16x7.03	65.11x5.23	C-1-8-3
④	X7224092-7	62.85x10.37	60.80x8.57	C-1-8-4
⑤	X7224092-7	62.85x10.37	60.80x8.57	C-1-8-5

AMR DEV	10055-5	AMAVS		
MATL	FMS-1111	MATL ALLOCATION PLAN		
PLATE	1 OF 1	APPR		C-1-8
SIZE	6.4 x NOTED	DATE	2-18-74	
VENDOR	U.S. STEEL			
HEAT	C52301	REV	C	SH 1 OF 2

CONT'D ON SH 2

Figure 4.5-1 Sheet 1

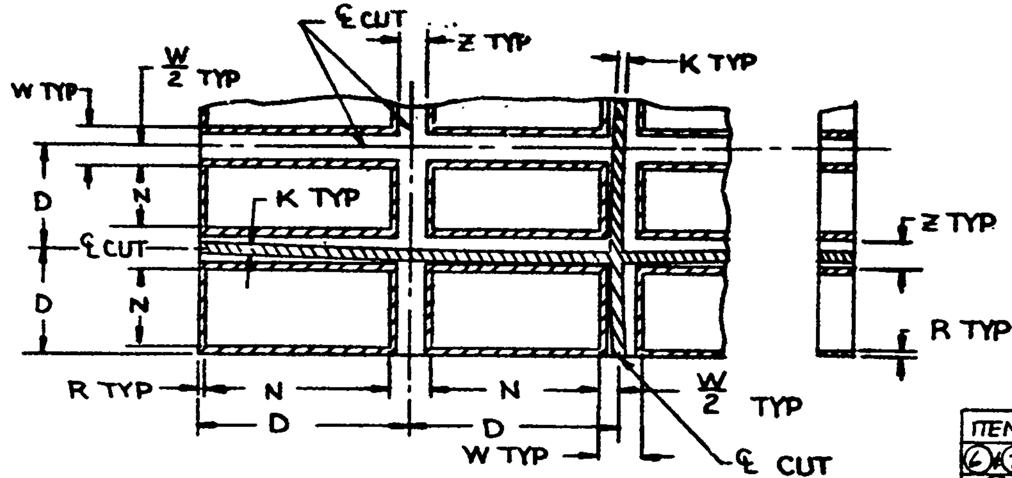


TABLE II

SYM	DEFINITION	DIM.
D	ROUGH CUT DIMENSION (MAX)	*
K	KERF OR SAW WIDTH	.30
N	NET ITEM SIZE	*
R	MIN MATL REMOVED	.40
T	DEPTH OF CUT (PLATE THICKNESS)	6.4
W	WIDTH BETWEEN ITEMS	1.30
Z	TOLERANCE ZONE FOR CUT	.50

* SEE TABLE I

TABLE I CONTD FROM SH 1

ITEM	PART NO	D MAX	N MIN	MATL TP NO
6 & 7	SEE NOTE 5	—	—	—
8	NRL/DWTT	7.0 x 13	—	C-1-8-8

AMAVS		
MATL ALLOCATION PLAN		
APPR		C-1-8
DATE		
REV	C	SH 2

Figure 4.5-1 Sheet 2

1. A coded serial number for each piece of material used to make a part. The number was used to establish traceability of a detail part.

2. The source of material, heat number, and in-house material request number for each sheet, plate, or box of special material allocated for this program.

3. The space allowed between each part stock size for separation cuts and the subsequent edge finishing operations on the part stock.

4. Allowances for edge clean-up on stock as received from the supplier.

Manufacturing engineering planners issued planning sheets to manufacturing departments to establish surface preparation, layout of cuts, identification (marking) of detail stock sizes, method of cutting the basic sheet, plate, or bar stock, and sequence of inspection for each piece of "as-received" stock. An example of this planning is shown as Figure 4.5-2.

Where multiple pieces are being cut from the basic stock, planning sheets are issued for each piece under the coded piece number. This planning will specify inspection sequence, material removal method, excess to be removed, heat treat as required, and other operations essential to make the basic stock acceptable for the next fabrication operation. Typical planning for a detail piece of stock is shown as Figure 4.5-3.

In fabrication the detail MAP number part is machined per planning to clean up the heat affected zones and any other surface finish or thickness requirements. After final inspection, it is stocked under the MAP detail part number and requisitioned out under the same number as raw stock to make the intended aircraft part.

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

PROTOTYPE OPERATION SHEET

Dept 232 FW355C -12-73

REQ.PER.SHIP L / R	NEXT ASSEMBLY	TV	EFFECTIVITY	DEPT.USE	DWG.CHG/ECN	CLASS CODE	PART NUMBER
							MAP No. C-3-13
					ITEM / IND / STA	TYPE CODE	NAME
					DISPOSITION / IF COMP THRU OPER.		REPLACES / TASK GR. / SHEET NO. 1 OF 2

SR CODE	CHA. CODE	MATERIAL GAGE AND TYPE	MATERIAL SPECIFICATION	MATERIAL SIZE
			10 Nickel FMS 1111	

PART NUMBER / TOOL NUMBER — QTY L/H — QTY R/H — PART NAME / TOOL CODE "MAP PLANNING" — DWG ZONE — FINAL INSP.

MANUFACTURING INSTRUCTIONS

OPER	
1	DRAW MATERIAL FROM STOCK. AMR NO. ______ ITEM NO. ______
5	INSPECT - VERIFY AND RECORD HEAT LOT NO. HEAT NO. ______ LOT NO. ______
10	ROCKWELL PER NDTS 15.04 (RC ______) (FOR ST - CONDITION)
15	IDENTIFY WITH MAP NO. C-3-13 ON EDGE AND FACE OF MATL.
20	INSPECT - SURFACE OF MATERIAL AND DETERMINE SMOOTHNESS REQUIRED FOR ULTRASONIC INSPECTION PER NDTS 50.00
25	MILL (1) SIDE OF PLATE TO CLEAN UP (IF NECESSARY TO INSPECT)
30	MILL OPPOSITE SIDE TO CLEAN UP (IF NECESSARY TO INSPECT)
35	INSPECT SURFACE FINISH (IF MILL OPERATIONS WERE PERFORMED)
40	ULTRASONIC INSPECT PER NDTS 50.00
45	STRIP MARK (1) SIDE OF MATERIAL WITH MAP NO.
50	LAY OUT AND IDENTIFY MAP AND PART NO'S AS INDICATED:

NOTE: IDENTIFY EACH PART NUMBER WITH LETTER "T" WHEN TRACEABILITY IS REQUIRED AS NOTED IN TABLE BELOW.

MAP NO.	PART NO.	MAP NO.	PART NO.
C-3-13-1	(X7223944-7T)	C-3-13-5	(X7223945-7T)
C-3-13-2	(X7223944-7T)	C-3-13-6	(X7223945-7T)
C-3-13-3	(X7223944-7T)	C-3-13-7	(X7224084-7)
C-3-13-4	(X7223944-7T)	C-3-13-8	(X7224084-7)

Figure 4.5-2 Sheet 1

FLOW		AUTH.	CHECKED BY:	PLANNER	DATE	FINAL INSP
CHG LET	MC/RC	ALTERATION				

PROTOTYPE OPERATION SHEET

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation
Dept 232 FW355C -12-73

REQ PER SHIP L	R	NEXT ASSEMBLY	TV	EFFECTIVITY	DEPT USE	DWG. CHG/ECN	CLASS CODE	PART NUMBER
								MAP NO. C-3-13

ITEM	IND	STA	TYPE CODE	NAME

DISPOSITION	IF COMP THRU OPER.	REPLACES	TASK GR.	SHEET NO.
				2 OF 2

SP. CODE	CHA. CODE	MATERIAL GAGE AND TYPE	MATERIAL SPECIFICATION	MATERIAL SIZE
			10 NICKEL FMS 1111	

TASK CENT REFERENCE	OPER	PART NUMBER / TOOL NUMBER / MANUFACTURING INSTRUCTIONS	QTY L/H	QTY R/H	PART NAME	DWG ZONE / QTY ACCEPT L H	R H	FINAL INSP. ACCEPT STAMP
	55	TORCH CUT DETAIL MAP NO'S LISTED ABOVE						
	60	DEBURR						
	65	TAG-TRANSFER ALL IDENTIFICATION ON TO METAL TAGS, HEAT LOT (TRACEABILITY IF REQUIRED)						
	70	INSPECT						
	75	OIL-DIP PER P.S. 40.01-6						
	80	IDENTIFY REMNANT STOCK WITH MAP NO. C-1-8 AND RETURN TO MATERIAL STORES.						
	85	F/S ALL DETAILS						

Figure 4.5-2 Sheet 2

FLOW	AUTH.	CHECKED BY:	PLANNER	DATE	FINAL INSP
CHG LET	MC/RC	ALTERATION			

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation
Dept 232 FW355C -12-73

PROTOTYPE OPERATION SHEET

REQ. PER SHIP L / R	NEXT ASSEMBLY	TV	EFFECTIVITY	DEPT. USE	DWG. CHG/ECN	CLASS CODE	PART NUMBER
							MAP NO. C-3-13-1
					ITEM / IND / STA	TYPE CODE	NAME
					DISPOSITION / COMP. THRU OPER.	REPLACES	TASK GR. / SHEET NO. 1 OF 2

SP. CODE	CHA. CODE	MATERIAL GAGE AND TYPE	MATERIAL SPECIFICATION	MATERIAL SIZE
			10 NICKEL	MF-MAP NO. C-3-13

TASK CENT REFERENCE	OPER	PART NUMBER / TOOL NUMBER — MANUFACTURING INSTRUCTIONS	DWG ZONE / QTY ACCEPT LH RH	FINAL INSP. ACCEPT STAMP
		"AMAVS"		
	1	DRAW MATERIAL FROM STOCK MAP NO. C-3-13-1		
	5	INSPECT - VERIFY MATERIAL AND MAP NO.		
	10	VERIFY PART NO. ON STOCK AND/OR METAL TAG. RECORD FOR TRACEABILITY THE FOLLOWING: HEAT LOT NO. LOT NO. ____________ (IF REQUIRED ON DRAWING.)		
	15	INSPECT		
	20	VAPOR DEGREASE PER P.S. 40.01 PARA. 5.3		
	25	AGE TO STA CONDITION PER P.S. 26.01-10 (IF REQUIRED)		
	30	ROCKWELL		
	35	INSPECT		
	40	INSPECT (MACHINE SHOP AREA) RECORD SIZE OF ROUGH MATERIAL (____________)		
		NOTE 1: MAKE CERTAIN THAT .40 DIM. IS DIMENSIONED FROM NEAREST POINT OF CUT EDGE.		
		NOTE 2: CHECK MATERIAL INSIDE SCRIBE LINES TO SEE IF THE REMAINING MATERIAL IS EQUAL TO OR GREATER THAN THE "N" (NET STOCK) DIMENSIONS SHOWN IN TABLE 1 ON SHEET 2 OF MAP.		
	50	INSPECT		
	55	MILL (1) EDGE TO SCRIBE LINE.		

Figure 4.5-3 Sheet 1

FLOW		AUTH.	CHECKED BY:	PLANNER	DATE	FINAL INSP
CHG LET	MC/RC	ALTERATION				

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation
Dept 232 FW355C -12-73

PROTOTYPE OPERATION SHEET

REQ.PER.SHIP L / R	NEXT ASSEMBLY	TV	EFFECTIVITY	DEPT.USE	DWG.CHG/ECN	CLASS CODE	PART NUMBER
							MAP NO. C-3-13-1
					ITEM / IND / STA	TYPE CODE	NAME
					DISPOSITION / IF COMP. THRU OPER.	REPLACES / TASK GR.	SHEET NO. 1 OF 2

SR. CODE	CPA. CODE	MATERIAL GAGE AND TYPE	MATERIAL SPECIFICATION	MATERIAL SIZE
			10 NICKEL	MF-MAP NO. C-3-13

TASK CENT REFERENCE	OPER	PART NUMBER / TOOL NUMBER — MANUFACTURING INSTRUCTIONS	DWG ZONE / QTY ACCEPT L H	R H	FINAL INSP. ACCEPT STAMP
	60	MILL OPPOSITE EDGE TO 3.95 DIM. PER TABLE 1, SHEET 2 OF MAP			
	65	MILL (1) END TO SCRIBE LINE			
	70	MILL OPPOSITE END TO 7.25 DIM. PER TABLE 1, SHEET 2 OF MAP			
	75	DEBURR			
	80	VERIFY TAG PART NO. AND TRACEABILITY NO. IF REQUIRED			
	85	OIL-DIP PER P.S. 44.01-6			
	90	INSPECT			
	95	F/S			

Figure 4.5-3 Sheet 2

FLOW		AUTH.	CHECKED BY:	PLANNER	DATE	FINAL IKSP
CHG LET	MC/RC	ALTERATION				

SECTION 5

FACTORY PROGRESS

Manufacturing of detail parts began immediately in Phase III since large quantities of material were available. Fabrication was in accordance with production schedules shown in Section 4.0.

5.1 FABRICATION OF WCTS

The major items to be fabricated for Station 1 were the lower plate, reinforcing lugs, drag brace fittings, longeron fittings, and bonded panels. Other long lead items including Y_F932 and Y_F992 bulkheads were started immediately on receipt of 10 nickel steel material.

5.1.1 Lower Plate Assembly

Material for the lower plate and reinforcing lugs arrived March 15, 1974, and priority was established for flame cutting the 1.9-inch-thick 10 nickel steel. The plate size was 84 inches wide by 323 inches long. The plate was flame cut per MAP No. C-1-3 shown in Figure 5.1.1-1.

Special tracing templates (MSLOs) were made from a NC layout which established the flame cut perimeter lines 1.00 inch from the finished plate size. The template was painted white and the special tracing table was painted black to establish maximum contrast for the electric eye tracer to follow. Figure 5.1.1-2 shows the set-up of table, template, and follower. Figure 5.1.1-3 shows the plate and cutting torch.

A general operating procedure was written as follows.

<u>Operation Sequence Lower Plate Flame Cutting</u>

I. Preparation and Layout

A. Lay out longitudinal reference line on the plate per MSLO X7224175. This reference line is drawn between the centers of the pivot lug holes on each end of the plate.

REVISIONS			
SYM	DESCRIPTION	APPR	DATE

ITEM	PART NO.	MATL TR NO.	NOTE 3
1	X7224175-7	C-1-3-1	FC
2	X7224176-7	C-1-3-2	FC
3	X7224176-8	C-1-3-3	FC
4	X7224176-9	C-1-3-4	FC
5	X7224176-10	C-1-3-5	FC

ITEM	PART No	"D" MAX	"N" MIN	MATL TR No
6	NRL/DWTT	13.0 x 13.0	—	C-1-3-6

4 △ DENOTES .50 DIA HOLE(10)PLACES FOR FLAME CUT STARTING & ENDING POINTS.
3. FC INDICATES FRACTURE CRITICAL PART. TRACEABILITY REQD PER X7224199
2. ALL ITEMS DIM. FOR FLAME CUT
1. ALL REMNANTS MUST BE MARKED WITH BASIC MAP NO.
NOTES (EXCEPT AS SHOWN)

AMR DEV	10053-7	AMAVS	
MATL	FMS-1111	MATL ALLOCATION PLAN	
PLATE	1 OF 1		
SIZE	1.9x84x324	APPR [illegible]	C-1-3
VENDOR	U. S. STEEL	DATE [illegible]	
HEAT	C52299	REV	SH 1 OF 2

Figure 5.1.1-1 (Sheet 1)

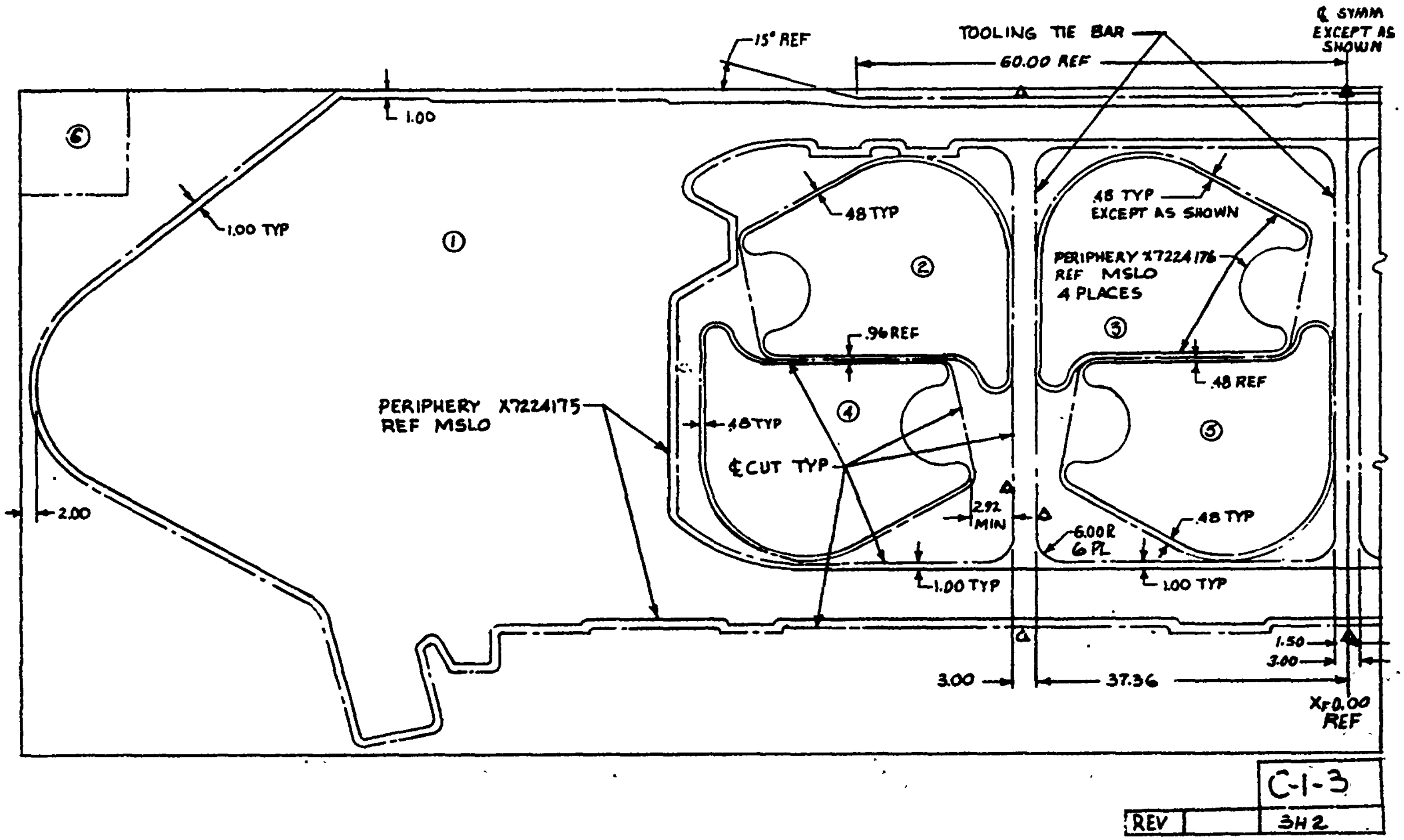


Figure 5.1.1-1 (Sheet 2)

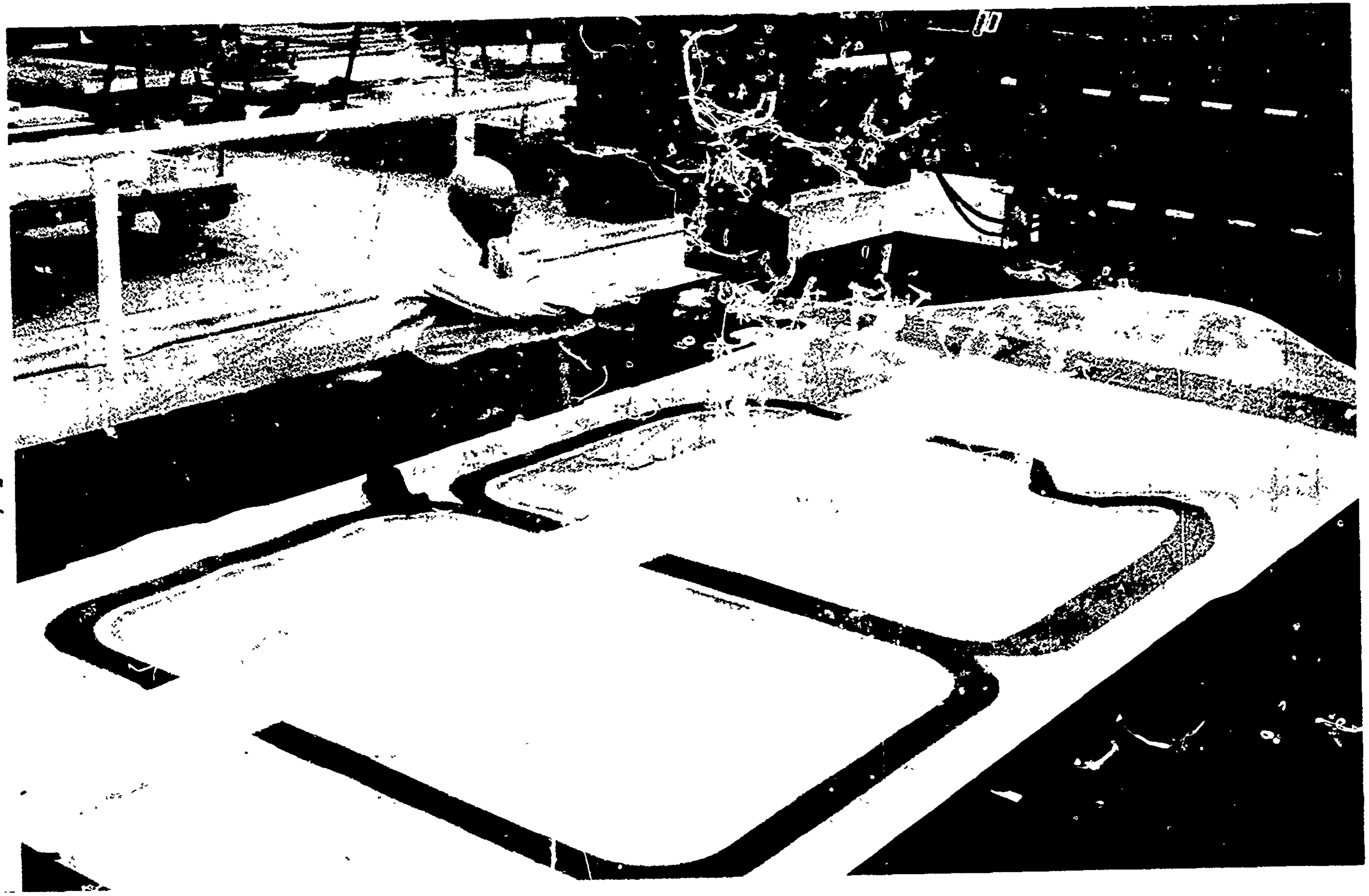


Figure 5.1.1-2 TORCH CUT TRACING TEMPLATE SET-UP

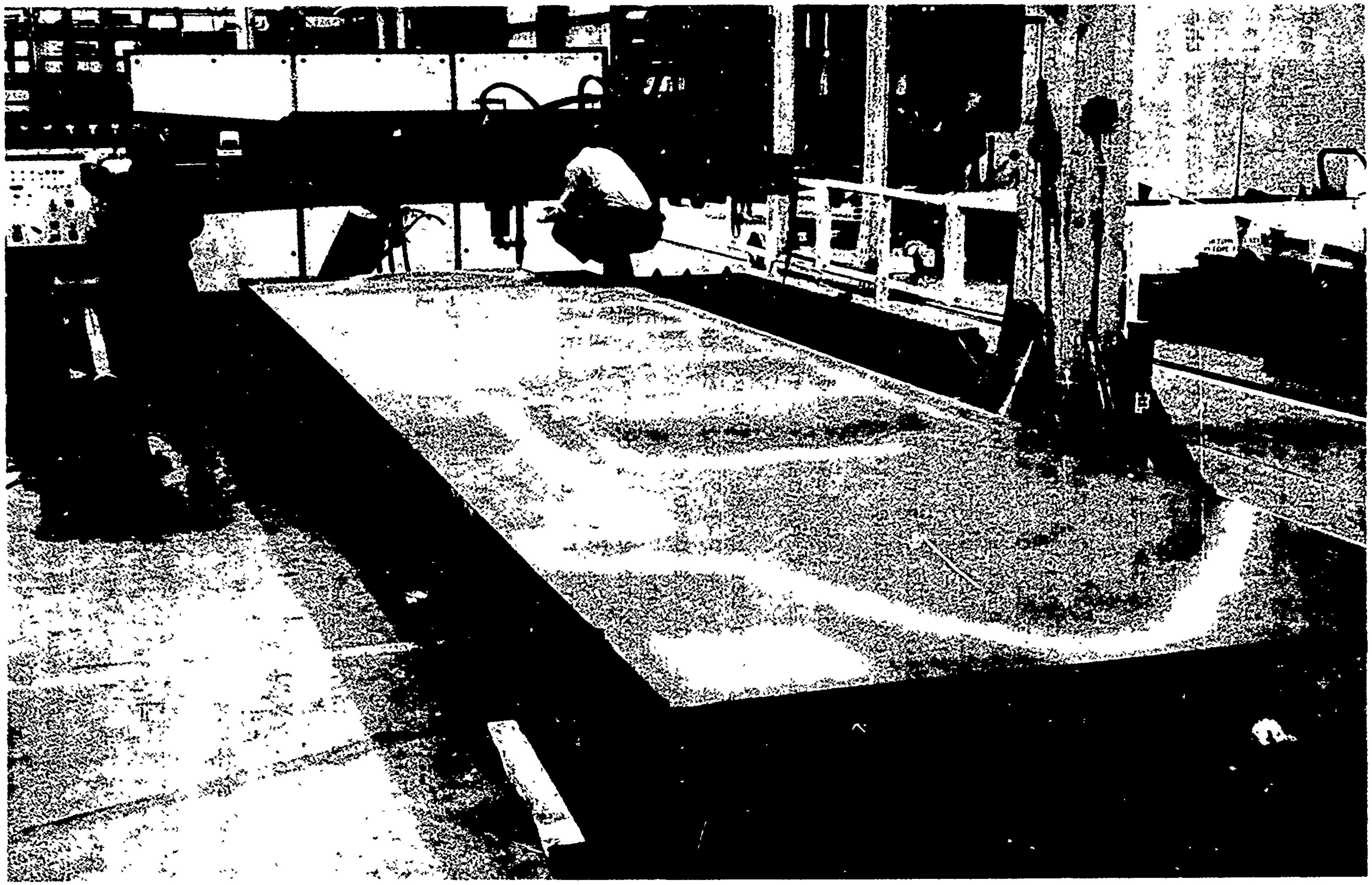


Figure 5.1.1-3 LOWER PLATE SET-UP ON CUTTING TORCH

B. Lay out CL of plate at station XF0.00.

C. Locate MSLO X7224175 on the lower plate using XF0.00 and the longitudinal reference line. Prick punch points representing the pivot lug hole center and four points representing the hole center of X7224176 lug reinforcing plates. Draw soapstone line around the periphery of the lower plate from XF0.00 to the outboard edge using edge of MSLO X7224175 as guide. Remove MSLO X7224175.

D. Locate MSLO X7224176 (part 1 and part 2) on the plate using longitudinal reference line and coordination points (corresponding to the center of the hole in the lug reinforcement plates). Make soapstone line to edge of MSLO to denote periphery of cutouts.

E. Relocate MSLO X7224175 on opposite end of plate using XF0.00 and longitudinal reference lines.

F. Perform operations as described in paragraph I.C. and I.D. (provide layout for opposite end of plate).

G. Drill .50 diameter holes (10) using the Bux-Magnetic drill unit. See MAP-1-3 for approximate locations of these start and stop holes.

   1. One starter hole will be required in each of the four cutouts. These holes will be located adjacent to the tooling tie bars to minimize potential flame-out damage.

   2. Six starter holes will be required on the outside periphery of the plate. A starter hole will be located on the forward and aft side at each of the following locations:

      a. CL tie bar at station 38.86 (2 places)

      b. $X_F0.00$

II. Flame Cutting

A. Locate plate on cutting table and MSLO X7224175 on guide table. Support portion of plate protruding on the south side of the cutting table (overhanging part of plate).

B. Align MSLO and plate using longitudinal reference lines to insure parallelism and location.

C. Make test run with cutting head off to check flame path with the soapstone lines.

D. Flame cut area from Station XF 38.86 to outboard edge of lower plate.

E. Locate MSLO X7224176 part 1 to MSLO X7224175 using longitudinal reference line and two coordination points.

F. Make test run to insure that torch follows soapstone mark denoting CL cut of internal cutout. Flame cut using starter hole.

G. Relocate plate on cutting table so that area between X_F 38.86L and X_F 38.86R is on table. Remove MSLO X7224176 part 1 and realign MSLO X7224175.

H. Make test run to insure that torch follows soapstone marks. Flame cut from starter hole at X_F 38.86 to X_F 0.00 (forward and aft sides).

I. Locate and align MSLO X7224176 part 2 on MSLO X7224175 using longitudinal reference line and two coordination points. Make test run with torch off to insure cutting to soapstone line for cutout between tie bar at X_F 38.86 and X_F 0.00. Flame cut cutout.

J. Remove MSLO X7224176, reverse MSLO X7224175 and realign with plate.

K. Make test run for flame cutting from starter hole at X_F 0.00 to starter hole at X_F 38.86 (forward and aft sides). Flame cut using MSLO as guide.

L. Locate and align MSLO X7224176 part 2 on MSLO X7224175 as described in paragraph II.I. Make test run and flame cut cutout located between X_F 0.00 and X_F 38.86.

M. Relocate plate so that area between X_F 38.86 and outboard edge is in the torch cutting area. Support end protruding from north end of cutting table. Realign MSLO X7224175 with the plate and make test run. Flame cut from starter hole at X_F 38.86 to outboard end of lower plate.

N. Locate MSLO X7224176 part 1 on MSLO X7224175 using longitudinal reference line and two coordination points.

Make test run to insure that torch follows soapstone line. Flame cut the cutout in plate outboard of X_F 38.86.

O. Remove plate from table and forward MAP-1-3-1 to next planning operation.

P. Trim MSLO X7224176 part 1 to CL flame cut line for MAP-1-3-2 and MAP-1-3-4.

Q. Flame cut.

R. Trim MSLO X7224176 part 2 to CL flame cut line for MAP-1-3-3 and MAP-1-3-5.

S. Flame cut.

The flame cutting operations were accomplished without incident. Figure 5.1.1-4 shows the plate after successful completion of flame cutting operation. The actual flame cutting operations consumed approximately two working days. The overall time from receipt of stock to delivery of the plate to the NC machine was nine working days.

Maximum warpage of the cutout plate was established at approximately .25-inch when the plate was placed on the NC machine bed. This maximum distortion occurred at one end only. The decision was made against a straightening operation in favor of a series of light cuts on opposite sides of the plate. Cause of the warpage was not determined.

The first machining operations of .150-inch maximum cut cleaned up approximately 80 percent of the surface. The second side was machined likewise. The plate was again turned to original side and successive passes on each side brought the plate to within tolerance on thickness. Figure 5.1.1-5 shows the plate and machine in the process of being machined to thickness.

Machining and drilling of the lower plate was completed on schedule. Figure 5.1.1-6 shows the plate after all machining and during final dimensional inspection.

Figure 5.1.1-7 shows the X7224176 reinforcing lugs in unfinished condition. After machining the lugs were pilot drilled to match the pattern in the plate. Set up bolts were used to hold upper and lower reinforcing lugs in relation to the plate while

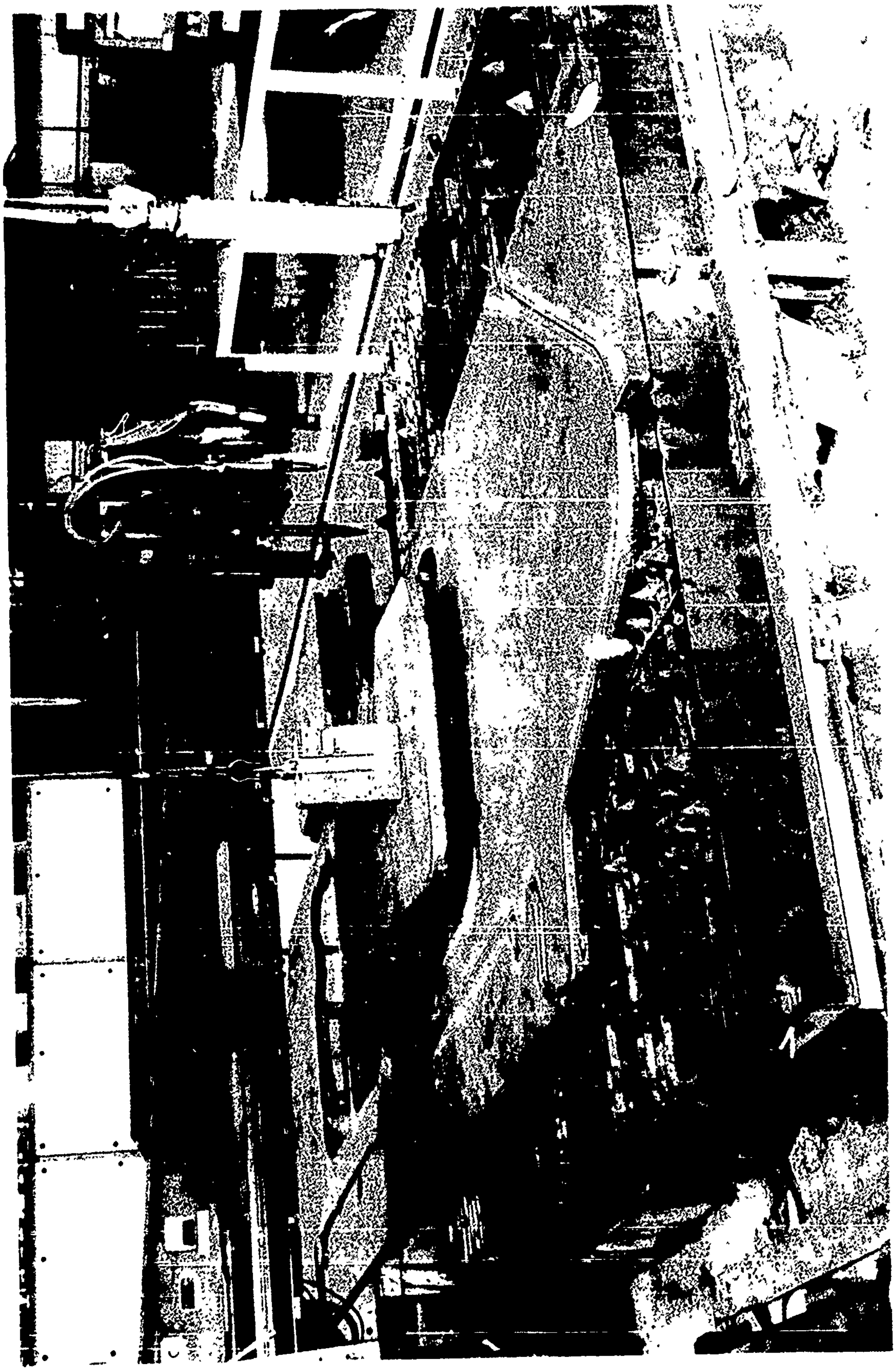


Figure 5.1.1-4 LOWER PLATE AFTER FLAME CUTTING

Figure 5.1.1-5 LOWER PLATE BEING MACHINED TO THICKNESS

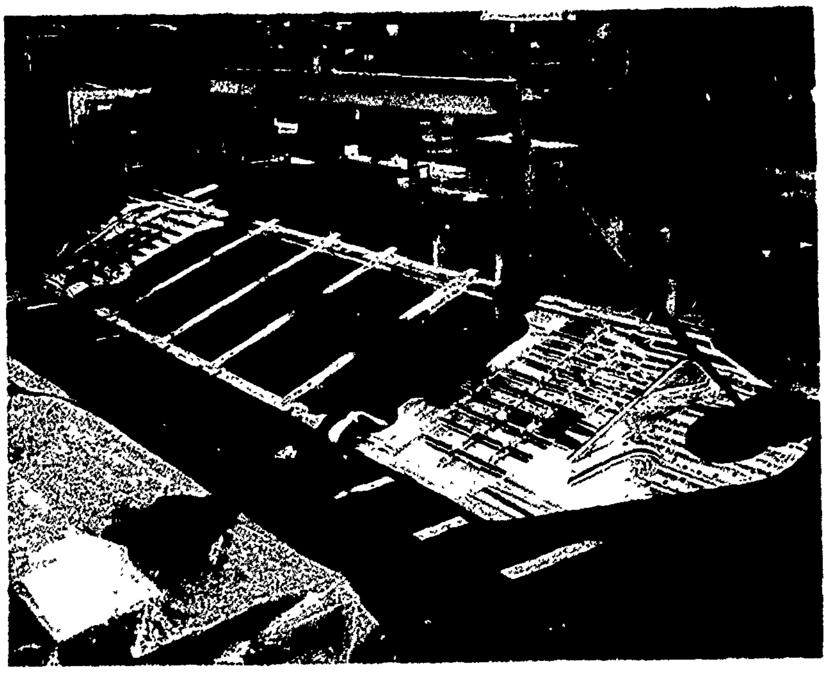


Figure 5.1.1-6 DIMENSIONAL INSPECTION OF LOWER PLATE

Figure 5.1.1-7 REINFORCING LUG PARTIALLY MACHINED

holes for taper-lok bolts were enlarged to taper ream size. The details are currently in final drilling and finishing status.

5.1.2 X7224173 Panel, Lower Plate - Center

This adhesive bonded panel is made of 6Al-4V beta annealed titanium skins and aluminum core. Figure 5.1.2-1 shows the panel immediately after bonding.

5.1.3 X7224181 Beam, MLG Drag Brace Support

The drag brace support shown in Figure 5.1.3-1 is a machined 6Al-4V beta annealed titanium fitting.

5.1.4 X7224071 and X7224091 Welded Bulkhead Segments of 10 Nickel Steel

These segments are made from four 10 nickel steel details machined from plate stock. Details were flame cut from plate stock. Two details were used to make the upper "T" cap. The "T" caps were electron beam and GTA welded in house as explained in Sections 4.1.5 and 4.2.7. Figure 5.1.4-1 shows the EB welded assembly.

The under side or lower surface of this EB weld required repairs by GTA. The combination of welds worked very good. Class 1 inspection was made which included X-ray and ultrasonic inspections.

The lower cap and web were GTA welded in house as described in Sections 4.1.6 and 4.2.7. These welds received Class 1 inspection. Some minor repairs were made by GTA. Figure 5.1.4-2 shows the lower web and cap assembly.

Excess material was left at the upper weld line of the web. The web was trimmed and grooved for welding to match the upper cap weldment. Figure 5.1.4-3 shows the completed welded segment. The upper and lower weldments were made by GTA.

The completed welded segment was furnace aged at 950°F for eight hours as a post weld heat treatment. A minimum of .200-inch excess material was left on all surfaces for finish machining. The segment was programmed for NC machining. Tooling tabs were added in the web area for coordinating machining of both sides of the web and the upper and lower caps. Figure 5.1.4-4 shows the segment in its holding fixture on the NC machine.

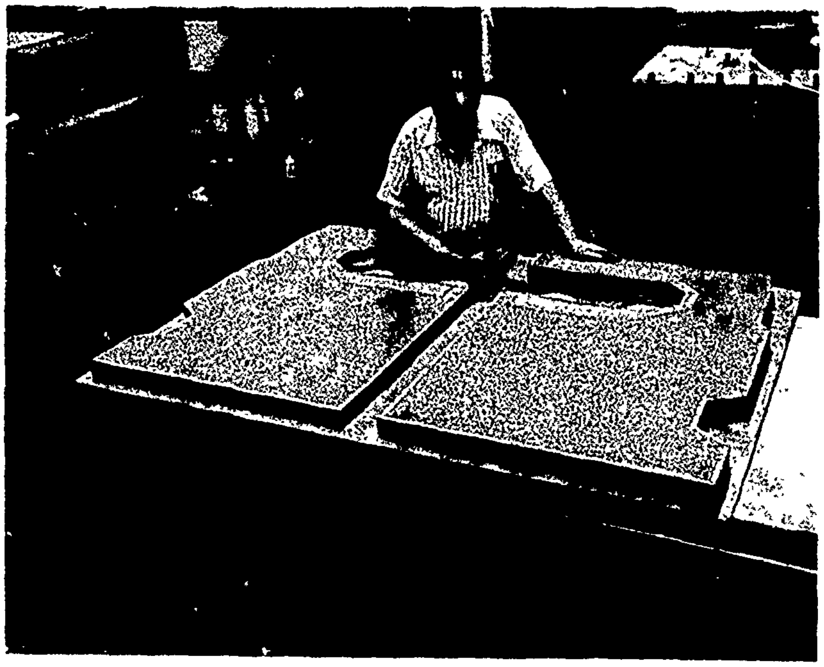


Figure 5.1.2-1 BONDED PANEL, LOWER PLATE CENTER

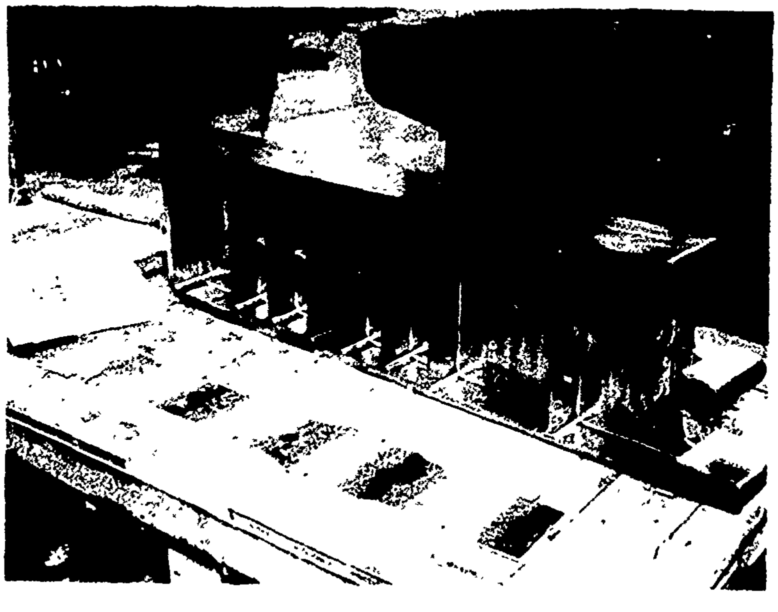


Figure 5.1.3-1 Y_F947 BEAM, MLG DRAG BRACE SUPPORT

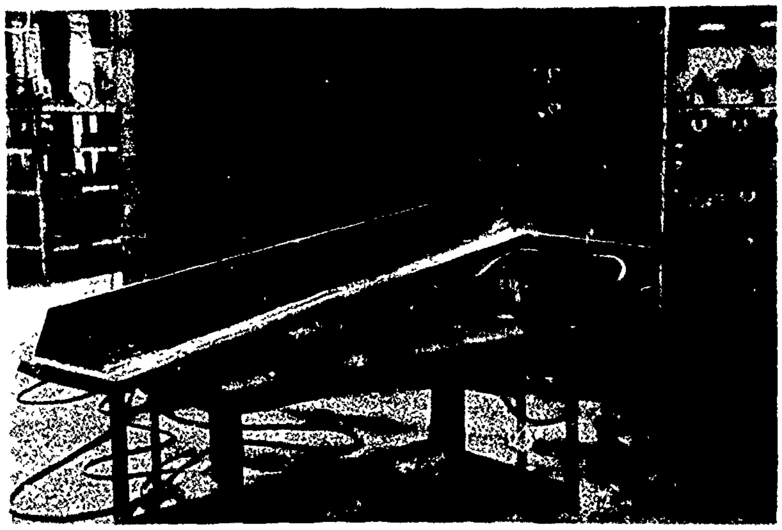


Figure 5.1.4-1 ELECTRON BEAM WELDED TEE CAP

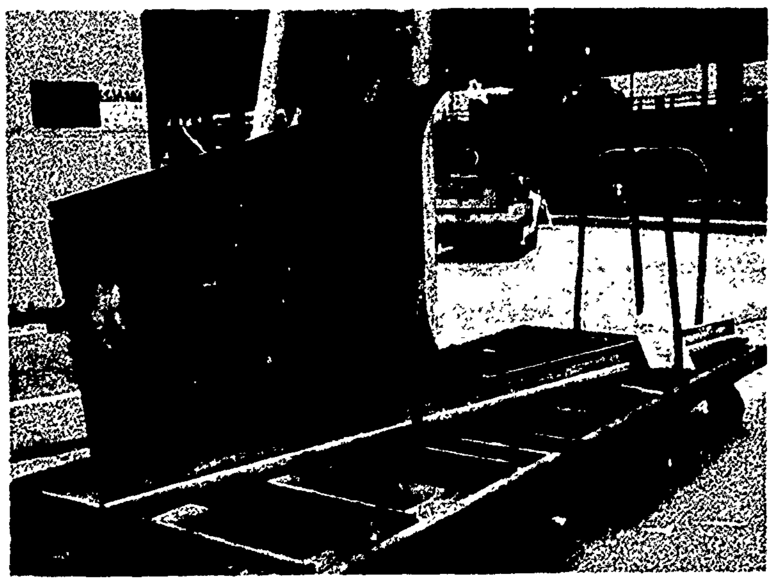


Figure 5.1.4-2 LOWER CAP AND WEB GTA WELDED ASSEMBLY

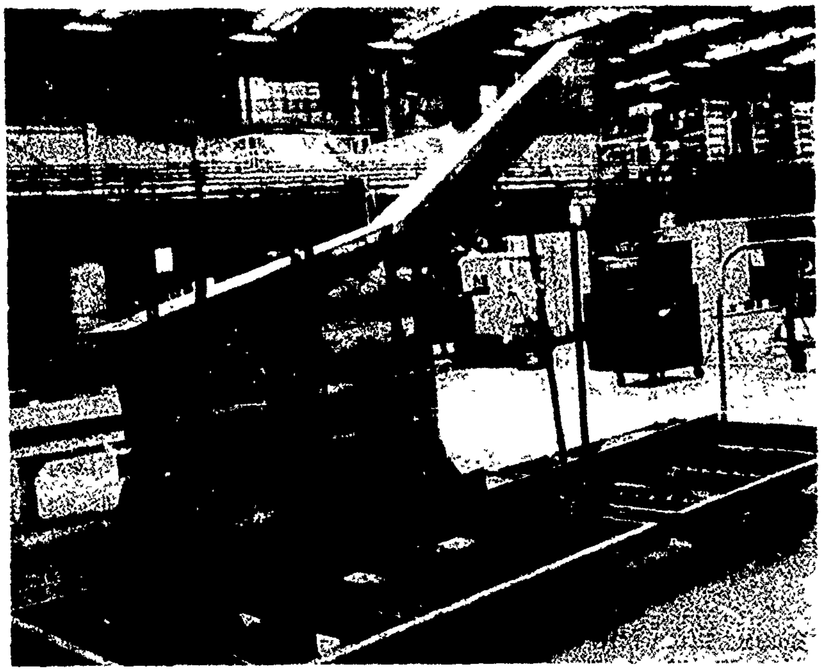


Figure 5.1.4-3 BULKHEAD SEGMENT, WELDED ASSEMBLY

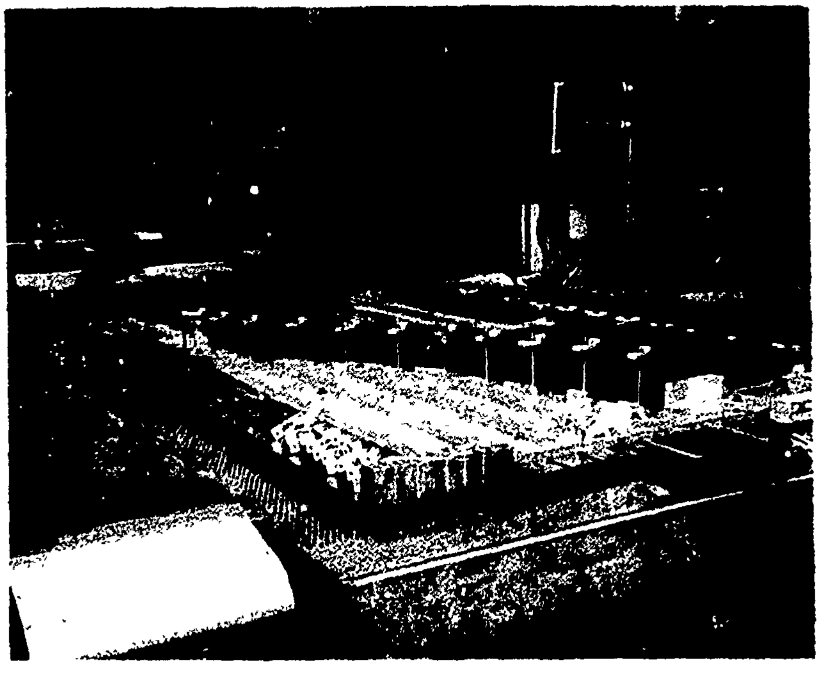


Figure 5.1.4-4 NUMERICAL CONTROL MACHINING OF 10 NICKEL BULKHEAD SEGMENT

5.1.5 WCTS Assembly Area

Figure 5.1.5-1 shows the areas designated for assembly of the WCTS. In the foreground is the Station 1 lower plate assembly fixture. The Station 2 thru 5 assembly fixture is shown in the background. Utilities are installed in the area and work platforms are fabricated.

5.2 FABRICATION OF FORWARD AND AFT SIMULATED FUSELAGE SECTIONS

Details and assemblies for the simulated fuselage structures are substantially complete.

5.2.1 Forward Simulated Fuselage

All frames for the forward fuselage were subassembled and pilot holes drilled for the attach skin fastener pattern. Figure 5.2.1-1 shows the general assembly area where the frames and longerons of the forward section were assembled. Longerons were mated to the dummy WCTS tool. The tool doubled as a coordinating tool for the WCTS assembly tool.

5.2.2 Aft Simulated Fuselage Section

All details for this section are complete. Longeron beam assemblies are planned.

Figure 5.2.2-1 shows the upper centerline longeron beam assembly 603FTB202.

Figure 5.2.2-2 shows the 603FTB204 longeron shelf assembly.

Figure 5.2.2-3 shows the aft bulkhead assembly at Station Y_F1050.

Major subassemblies of the aft simulated fuselage will be assembled to the dummy WCTS prior to assembly with the aft upper test fixture.

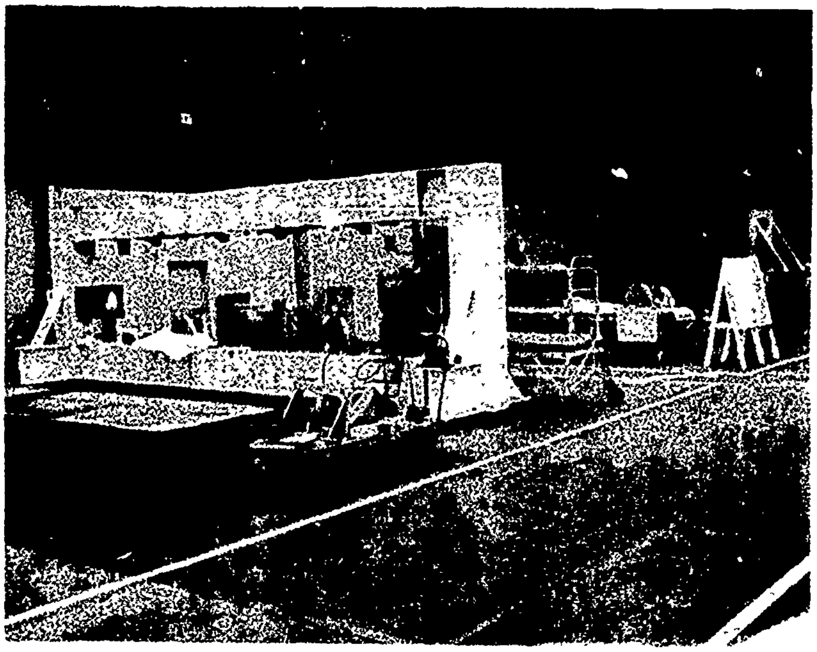


Figure 5.1.5-1 WCTS FINAL ASSEMBLY AREA

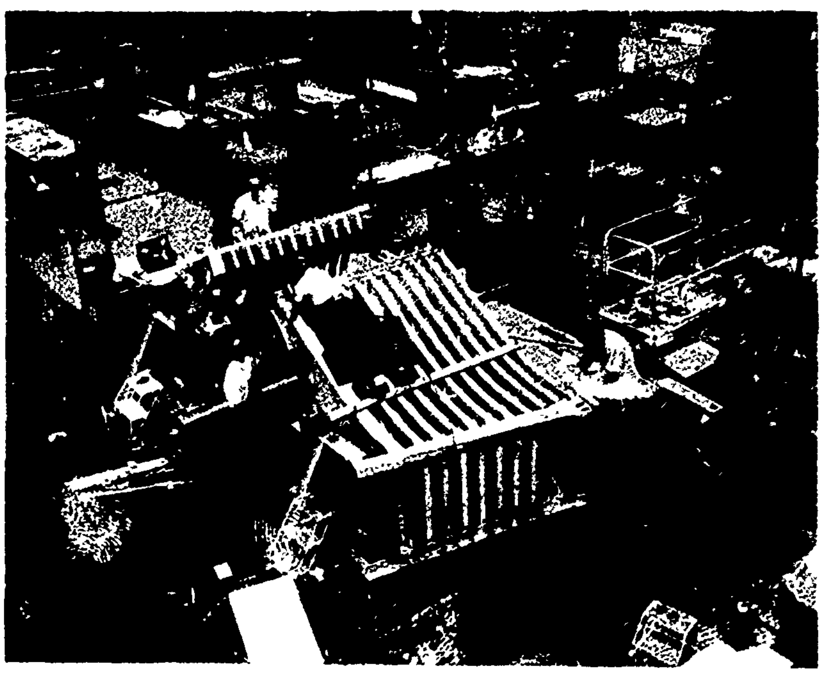


Figure 5.2.1-1 SIMULATED FUSELAGE ASSEMBLY AREA WITH FORWARD FUSELAGE FRAMES AND LONGERONS IN PLACE

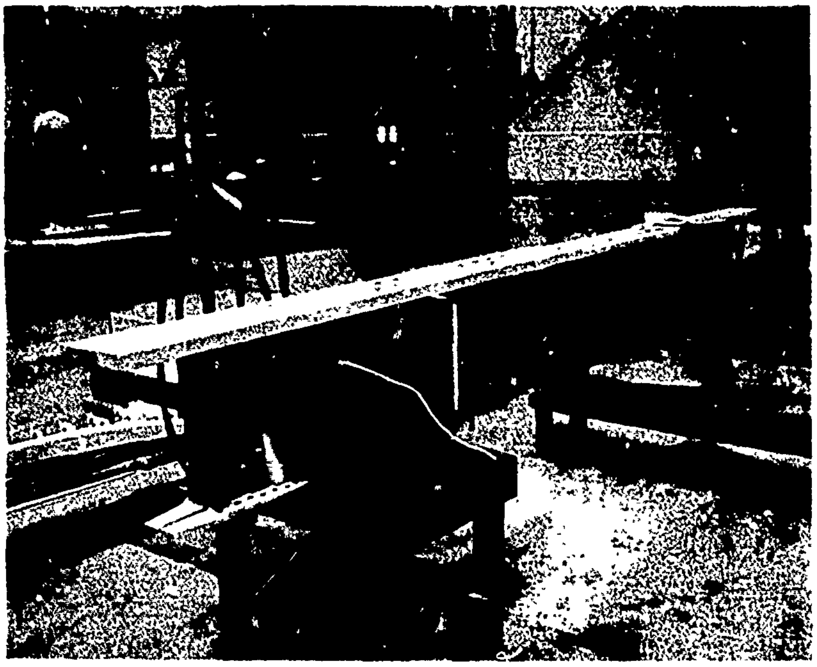


Figure 5.2.2-1 UPPER CENTERLINE LONGERON BEAM ASSEMBLY
AFT SIMULATED FUSELAGE ASSEMBLY

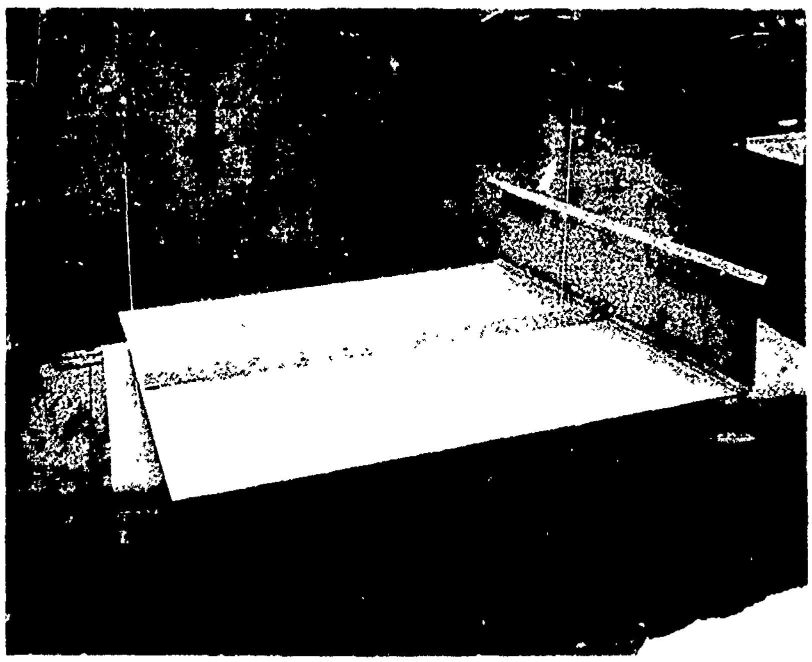


Figure 5.2.2-2 LONGERON SHELF ASSEMBLY 603FTB204

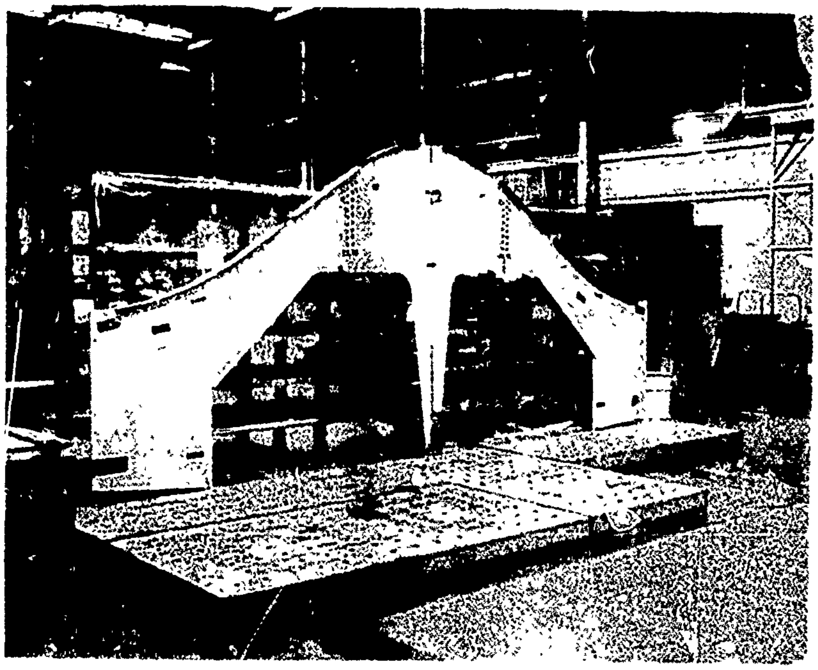


Figure 5.2.2-3 STATION Y_F 1050 BULKHEAD 603FTB201

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13. ABSTRACT

This report covers the design, analysis, manufacturing and testing done during the last portion of Phase II, detail design, and the first portion of Phase III, Fabrication, of the Advanced Metallic Air Vehicle Structure (AMAVS) program. All drawings for the wing carrythrough structure, simulated fuselage and test fixture were completed and significant progress was made in manufacturing each of these items.

A weight reduction effort was necessary in order to meet the weight reduction goal for the wing carrythrough structure after incorporation of the updated loads data. This effort has been completed and was successful.

Delivery of material for manufacture of the wing carrythrough structure is complete except for the 10 Ni steel for the upper lugs. This material is expected in July 1974.

Manufacturing procedures successfully completed include flame cutting of thick plates of 10 Ni steel and beta annealed 6Al-4V titanium, Electron Beam (EB) welding of both of these materials, Gas Tungsten Arc (GTA) welding of 10 Ni steel, machining of 10 Ni steel and 6Al-4V titanium and bonding of titanium sandwich panels. Most tooling for detail parts is complete and the assembly fixtures are complete.

Assembly of the simulated fuselage structure has been started and is scheduled for completion in July 1974. All of the test fixture will be completed by December 1974.

Additional materials and component testing has been approved as an addition to the original contract. Plans for these tests have been made and some tests are being conducted. All materials and component testing authorized by the original contract has been completed.

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